

# CALIFORNIA FISH AND GAME

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## TABLE OF CONTENTS

|                                                                                                                           | Page                            |
|---------------------------------------------------------------------------------------------------------------------------|---------------------------------|
| First Report of Sardine Tagging in California-----                                                                        |                                 |
| -----John F. Janssen, Jr.,                                                                                                | 190                             |
| ✓ Trout and Salmon Marking in California-----                                                                             | Leo Shapovalov 205              |
| Experiments in Hatching Steelhead Eggs in Gravel-----                                                                     |                                 |
| -----Leo Shapovalov                                                                                                       | 208                             |
| Fishways-----                                                                                                             | John Spencer 215                |
| ✓ Notes on Sardine Gear Changes at Monterey-----                                                                          | J. B. Phillips 221              |
| Setting and Survival of Spat of the Olympia Oyster, <i>Ostrea lurida</i> ,<br>on Upper and Lower Horizontal Surfaces----- | Paul Bonnot 224                 |
| The Chukar Partridge of Asia-----                                                                                         | Gordon H. True, Jr. 229         |
| The Chukar Partridge in California-----                                                                                   | August Bade 233                 |
| California's Junior Game Patrol-----                                                                                      | M. F. Joy, Jr. 237              |
| Editorials and Notes-----                                                                                                 | 243                             |
| Bureau of Marine Fisheries-----                                                                                           | 243                             |
| Two New Patrol Boats Placed in Service-----                                                                               | E. L. Macaulay 243              |
| B. D. Marx Greene-----                                                                                                    | Richard S. Croker 244           |
| The Mollusks of Lake Tahoe-----                                                                                           | G. D. Hanna and A. G. Smith 244 |
| A Silver Salmon at Los Coronados Islands-----                                                                             | W. L. Scofield 245              |
| ✓ Monterey Spanish Mackerel Taken at Long Beach-----                                                                      |                                 |
| -----Richard S. Croker                                                                                                    | 245                             |
| ✓ Snake Eel, <i>Ophichthus triserialis</i> , Taken off San Pedro-----                                                     |                                 |
| -----Frances N. Clark                                                                                                     | 246                             |
| ✓ Further Notes on the Jumbo Squid, <i>Dosidicus gigas</i> -----                                                          |                                 |
| -----Richard S. Croker                                                                                                    | 246                             |
| Two New Sardine Bulletins, a Review-----                                                                                  | W. L. Scofield 247              |
| Graphic History of the Commercial Fish Catch, a Review-----                                                               |                                 |
| -----Geraldine Conner                                                                                                     | 249                             |
| Marine Fishes of Southern California, a Review-----                                                                       |                                 |
| -----Richard S. Croker                                                                                                    | 250                             |
| Marine Game Fishes of the Pacific Coast, a Review-----                                                                    |                                 |
| -----Richard S. Croker                                                                                                    | 250                             |
| Statistical Reports-----                                                                                                  | 251                             |

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# FIRST REPORT OF SARDINE TAGGING IN CALIFORNIA <sup>1</sup>

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## Introduction

With the rapid growth of the sardine canning and reduction industry in California, continued operation of plants in British Columbia, and recent expansion of the industry into Washington and Oregon, has come an urgent need for solving the perplexing question of possible migrations of the sardine, *Sardinops caerulea* (Girard). We would like to know whether sardines occurring on the Pacific Coast of North America comprise a single population or whether various regions harbor distinct populations which mingle little or not at all with sardines in other localities. To formulate appropriate conservation measures, different methods of approach must be followed, depending upon whether the fish are migratory or not.

Evidence resulting from a long time study of the sardine, made by the California Division of Fish and Game, points to distinct migrations. Analyses of eighteen years' data on sizes, maturity, spawning grounds, anatomical characters and other factors indicate that the sardines of the Pacific Coast, from Canada to Mexico, constitute one homogeneous migratory population. These studies have led to the formulation of the following theory relating to sardine migrations: nearly all spawning takes place off southern and Lower California; the young fish remain in these southern waters until adolescence; then they commence to make northerly migrations, going at first as far as central California, and returning the following spring to southern California for spawning purposes; the older fish go farther and farther north at the close of each spawning season, so that by the time they are eight or ten years old they make annual migrations as far as British Columbia but return to southern California to spawn.

To corroborate this evidence—or disprove it—and to show the extent of migrations, the California Division of Fish and Game, in cooperation with the Biological Board of Canada and the Provincial Fisheries Department of British Columbia, inaugurated a tagging program in the spring of 1936 as an additional phase of the sardine investigation. The immediate purpose is to gain definite knowledge as to the movements of these fish throughout their range. However, as tagging technique improves—providing tagging mortality can be estimated—it may be possible to determine the proportion of the total population removed by fishing operations, as well as to approximate the size of the sardine population.

<sup>1</sup> Submitted for publication June, 1937.



From March 9, 1936 to May 10, 1937, the California Division of Fish and Game tagged 25,114 sardines in California waters. Although a large proportion of these fish were tagged very near the close of the fishing season and some after the close, 302 of these tags have been recovered in reduction plants in this State. As is to be expected, since

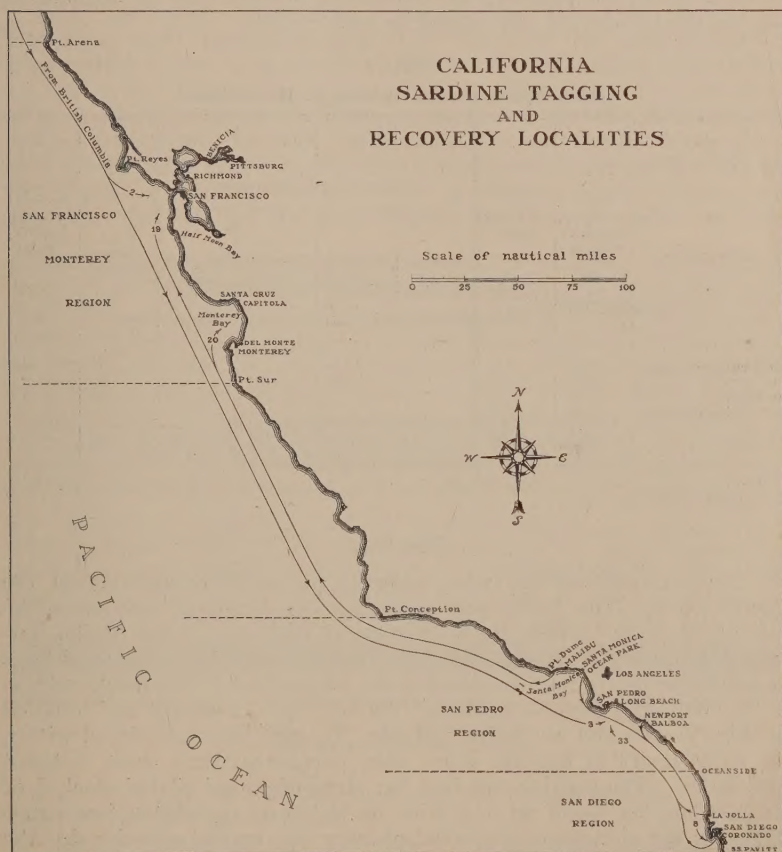


FIG. 24. A section of the California coastline showing, diagrammatically, major movements of tagged sardines from one fishing region to another, as indicated by recoveries during the 1936-1937 fishing season. Numerals represent the number of tags recovered in each locality which had been released at distant points. The number of local recoveries is not indicated. All localities in California where sardines have been tagged are shown.

tagged fish were usually released on or near the fishing grounds, most recoveries were from fish caught soon after tagging in the same fishing region as tagged. Several San Pedro tags were recovered, however, at San Francisco, Monterey and San Diego, and a few San Diego tags were recovered at San Pedro (see figure 24). In addition, 5 Canadian tags, which were placed in fish off Vancouver Island during the sum-

mer of 1936, have been recovered in California (Hart, 1937)<sup>2</sup>. As yet, recoveries are not numerous enough to be in themselves an indication of actual migrations of the main body of fish. However, such recoveries as have been made are in positive accord with the theory of migrations formulated from the various phases of the sardine investigation. Table 1 shows the recovery of California sardine tags by regions, as well as the number of fish tagged in each region.

TABLE 1  
Summary of California Sardine Tag Recoveries, 1936-1937 Season\*

| A                      | B                                                         | C                            | D                              | E                     | F                      | G                      | H                      | I                                               |
|------------------------|-----------------------------------------------------------|------------------------------|--------------------------------|-----------------------|------------------------|------------------------|------------------------|-------------------------------------------------|
| Tagging region         | Total number tagged, by regions, March, 1936 to May, 1937 | Percent- age of total tagged | Number of recoveries by region |                       |                        |                        | Total number recovered | Percentage recovered from each region's tagging |
|                        |                                                           |                              | Recovered at San Francisco     | Recovered at Monterey | Recovered at San Pedro | Recovered at San Diego |                        |                                                 |
|                        |                                                           | 100 B                        |                                |                       |                        |                        | 100 H                  |                                                 |
|                        |                                                           | Σ B                          |                                |                       |                        |                        | B                      |                                                 |
| San Francisco-Monterey | 8,222                                                     | 32.62                        | 4                              | 12                    |                        |                        | 16                     | 0.19                                            |
| San Pedro              | 14,715                                                    | 58.38                        | 19                             | 20                    | 201                    | 8                      | 248                    | 1.69                                            |
| San Diego              | 2,177                                                     | 8.64                         |                                |                       | 33                     | 5                      | 38                     | 1.75                                            |
| Lower California       | 91                                                        | 0.36                         |                                |                       |                        |                        |                        |                                                 |
| Totals                 | 25,205                                                    | 100.00                       | 23                             | 32                    | 234                    | 13                     | 302                    | 1.20                                            |

\* One tag recovered at the close of the 1935-1936 season at San Pedro a few days after its release in Santa Monica Bay included in table 1 and table 2.

### The Tag

An internal tag has been adopted for sardine marking on the Pacific Coast. This tag closely resembles one developed and used successfully by the United States Bureau of Fisheries in its Alaska herring investigation (Rounsefell and Dahlgren, 1933). External tags or marks generally used for tracing the migrations of fish would seldom if ever be found because sardines, like herring, are caught and handled in large masses and not as individuals. In addition, tags placed within the body cavity of fish are often more permanent than those fastened externally. The sardine tag is a flat strip of nickel plated steel,  $\frac{3}{4}$  of an inch long by  $\frac{5}{32}$  of an inch wide by  $\frac{1}{40}$  of an inch thick (see figure 25). On one side appears a serial number and on the opposite side the inscription "C.F.&G."

The method of tag recovery by means of electro-magnets is described in another section.

### Methods of Obtaining and Holding Sardines for Tagging

#### *Southern California.*

In southern California waters the fish are generally held for tagging in a live box installed on the after deck of a fast 45-foot fish and

<sup>2</sup> Since this report was submitted for publication, twelve additional California tags have been recovered. Belated reports of recoveries in California waters account for six of these. The remaining six were taken during July and early August, 1937, five in British Columbia and one in Oregon. The sardines bearing the six tags recovered in northern waters were released off southern California in February and March, 1937.



game patrol boat. This box is roughly 29 inches deep by 68 inches long by 28 inches wide. A small one-cylinder gasoline engine operates a pump which furnishes a constant stream of ocean water. A simple overflow arrangement at one end of the box prevents escape of fish and yet allows the water level to be regulated without decreasing the stream thrown by the pump, thus insuring ample aeration.

In California waters commercial sardine fishing is usually carried on at night during the dark of the moon, so that most of the tagging work has been done at night. The boat, with tagging crew aboard, cruises to the fishing grounds in search of a ring netter or purse seiner with sardines in her net. When one is found, and the fishermen are willing to donate a few fish to the cause, the patrol boat draws alongside the big seine skiff in order that a man with a long handled dip net can board her. By skillful maneuvering the patrol boat remains near the seine skiff, so that the man dipping fish from the seine can hand

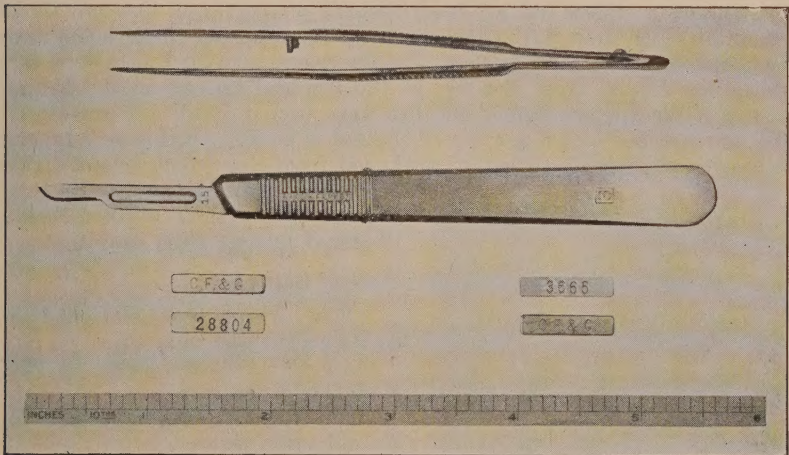


FIG. 25. California sardine tags, the scalpel for making an incision in the fish, and forceps for inserting the tag.

successive scoops of sardines to a man on the patrol boat to be put immediately into the live box.

If, as is often the case, the open sea is too rough to make tagging on the fishing grounds feasible, a hasty retreat is made to the nearest shelter, where anchor is dropped. Tagging then begins immediately under a flood light placed above the live box. By this method, 800 to 1600 sardines can be held at one time, depending upon the size of the fish. If the fish appear overcrowded, about half are transferred to an impounding net placed astern of the boat. This net is about 8 by 11 by 2½ feet deep. Occasionally, one load has been tagged and another obtained before the boats cease fishing for the night.

Although it is the most successful method yet tried for obtaining large numbers of sardines, the use of a small boat has definite limitations. In the first place, maneuvering very near a net in rough seas is hazardous due to the danger of sinking a section of the cork line,

which might result in the loss of the fishermen's entire catch. Secondly, approaching a net too closely involves the risk of its becoming fouled in the propellers. In addition, a boat small enough to have the necessary speed and maneuverability can carry only a relatively small live box. On the other hand, a speed boat, such as has been used in this work, is able to cover a large area in a short time. If fishermen are not finding fish in one locality other districts can be scouted the same night, as not all of the fleet from any one port seeks sardines in the same area. Consequently, failures to find fish have been few. Furthermore, when the ocean is too rough to make tagging practical, only a short time is required to reach shelter, so the fish are not held very long.

Although the above method is generally used in southern California, it is necessary to rely on live bait and wholesale market boats when the active canning and reduction season is not in progress. As sportsmen commonly use small sardines for bait, a few bait fishermen have been asked to hold any catch of large sardines they might accidentally make. These fish are held in small pounds or in live bait tanks essentially the same, but larger than our live box. At times, boats have been chartered with all or part of their crews. On such occasions sardines are dipped from the bag of the net and tagged on the fishing boat. After approximately 400 fish have been tagged, any remaining fish are released and a new set of the net is made. In this way tagged fish are not seriously scaled or weakened from close confinement. This method eliminates one handling of the fish and results in their being liberated in first class condition.

#### *Central California.*

The patrol boat stationed in central California, the 65-foot "Albacore," is too large to risk alongside a net, so a different means of obtaining fish had to be devised. An old squid lighter, approximately 24 feet long with an 8-foot beam, was converted into a live car. A rather substantial craft is necessary as it is often towed considerable distances at sea. Its deck is roughly 3 feet above the bottom with a 4 by 13-foot hatch covered by five hatch covers. Two openings, one 17 by 27 inches and the other 14 by 23 inches, cut in the bottom and covered with heavy wire mesh, provide circulation of sea-water. Each opening has a removable cover which can be clamped watertight. The volume of the fish compartment is approximately 185 cubic feet. Four oil drums partitioned from the main fish compartment, two forward and

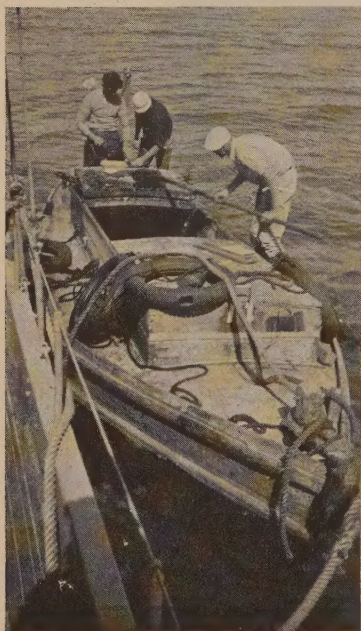


FIG. 26. Tagging from the live car in Monterey Bay. Photograph by Captain Lars Weseth, September, 1936.



two aft, offer enough buoyancy to prevent the craft from sinking too deeply when full of water and fish.

The live car is towed empty to the fishing grounds by the patrol boat. When a purse seiner is found with fish in her net, three men board the lighter and row her alongside the seine skiff or the cork line of the net. Hatch covers are removed and lashed down, and the covers

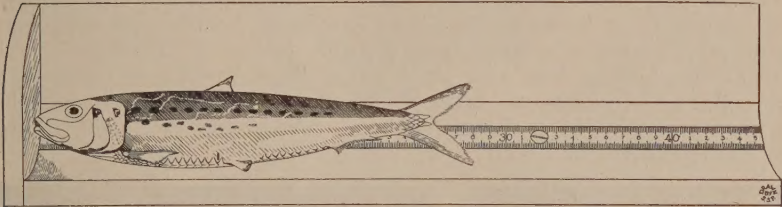


FIG. 27. Drawing of a sardine on the tagging board. The incision through which the tag is inserted is shown slightly anterior to the base of the ventral fin.

over the bottom holes removed so the craft fills with water. When approximately 500 to 1500 sardines, depending upon size, have been dipped into the fish compartment, hatch covers are fastened in place and the live car rowed a short distance from the net. The men now reboard the patrol boat which again takes the live car in tow.

Tagging is usually done at some sheltered locality. At the completion of tagging, covers are replaced over the bottom holes and the water removed from the live car to facilitate towing on the return trip to the fishing grounds.

The live car can be operated under conditions too rough to hazard a speed boat alongside a net, but its lack of speed is a decided disadvantage as the fish are kept in confinement a longer time. The speed boat can carry fish at 20 knots whereas the lighter can be towed no faster than 3 or 4—a considerable difference in speed when the fish have to be carried any distance.

### Tagging Procedure

From the outset, it was evident that within practically every batch of fish obtained for tagging, there would be a large range of sizes. As differential migrations of various size-groups have been strongly suspected, it seemed worthwhile to measure each fish tagged. Such data may also give some indication as to which sizes of fish survive the marking ordeal most successfully.

To facilitate tagging and measuring, a tagging board was constructed with a millimeter rule inlaid in the concave face at a 45 degree angle, as shown in figure 27.

In order to tag the fish as rapidly as possible, two people do the actual tagging, with usually a third person dipping the fish to the taggers and recording the length of each fish on previously prepared sheets. Each sheet has a series of one hundred consecutive numbers corresponding to the numbers on the tags to be used. Fish slime collecting on smooth hands makes holding a wriggling fish difficult without

exerting undue pressure, so the taggers usually wear cotton pallbearer's gloves on their left hands.

As tags are sorted in groups of one hundred some way had to be found to handle them conveniently in the field. One method is to pour each hundred group into a dish. A tag is picked up and its number read off followed by the length of the fish to the nearest half centimeter. The recorder enters the measurement after the appropriate tag number on his sheet. A better method is to have small boards each with four rows of 25 holes numbered from 0 to 99, inclusive. These holes are about one-third as deep as a tag is long. Tags, previously inserted in the appropriate holes, are taken consecutively as used, eliminating the necessity of reading each tag number before giving the length of the fish to the recorder.



FIG. 28. Making an incision in a sardine through which a tag will be inserted, and measuring its total length. Photograph by D. H. Fry, Jr., March, 1937.

With a small dip net the recorder scoops a sardine from the fish reservoir to the taggers. One man reaches into the dip net, grasps a fish around its body at the anterior end and holds it on the concave face of the tagging board with its head against the stop at the left and its ventral surface facing the operators. While one tagger is making an incision for the tag with a sharp scalpel held in the right hand his partner presses the upper and lower lobes of the caudal fin together slightly with his left hand and reads off the sardine's total length (see figure 28). At the same time the partner picks up a tag and places it part way within the incision with his right hand, then pushes it clear into the body cavity with a pair of forceps (see figures 29 and 30) so that it lies between the viscera and body wall. The tagged sardine is immediately dropped overboard.

The position of the incision depends somewhat upon the size of the fish to be tagged. It is slightly above the insertion of the left ventral





FIG. 29. The tag held in the foreground will be pushed into the incision when the scalpel is removed. Photographed by D. H. Fry, Jr., March, 1937.



FIG. 30. Pushing a tag into the body cavity of a sardine with a pair of forceps so it will lie between the viscera and body wall. Photograph by D. H. Fry, Jr., March, 1937.

fin in average sized fish, above and a little anterior to the fin in large fish, and above and behind the fin in very small fish.

Only once have tagged fish been held to be released as a school after tagging was completed. It seems advisable to release each one immediately after tagging as the fish weaken rapidly in confinement. Often tagged fish linger near the boat and school in small groups before disappearing. This is most noticeable at night when tagging takes place under a strong light. When there are fish in the impounding net, tagged individuals try and often succeed in joining their untagged companions by going over the cork line.

Several types of scalpels have been used at various times. The one proving most satisfactory is shown in figure 25. The blade is the same width as a tag and is sharp on one edge and at the end. Blades are relatively cheap and removable from the handle, so they may be replaced frequently, thus insuring a sharp edge at all times. No stop is put on the blades to regulate the depth of an incision, for after a little experience the scalpel can be controlled without danger of its cutting too deeply. Furthermore, the depth of an incision must vary in relation to the size of the fish.

No attempt has been made to use sterile instruments or tags.

Although the rate of tagging varies considerably under different conditions, a crew of three can tag approximately 300 fish an hour, whereas under very favorable conditions it is not unusual to tag 400 fish an hour.

### **Sizes of Sardines Tagged**

Although no holding tank experiments have been performed in order to estimate the percentage of mortality due to tagging or to determine the size of the smallest fish which may safely be marked with the tags now in use, such studies are contemplated for the future. Recoveries are still not numerous enough to indicate one way or another that a fair proportion of the smaller fish survive. Sardines under 180 millimeters, total length, are usually avoided. However, a few individuals as small as 145 millimeters have been tagged.

No size discrimination has been made in the case of larger sardines. All fish above 180 millimeters, total length, have been tagged; a few were as large as 340 millimeters. The majority of the sardines tagged to date represent a fair cross-section of the commercial catch, as is to be expected since they were obtained from nets of commercial boats. A few fish taken during the off season averaged smaller than the cannery and reduction plant catch.

It may become necessary in the future to use a tag smaller than the present one for young fish which are found in southern California and Lower California waters. Marking these young fish may help to determine if they later enter the commercial fishery, and if so, when and where.

### **Method of Tag Recovery**

Sardine tags are recovered by means of electro-magnets placed in the meal lines of reduction plants (Fry, 1937). Many whole fish, as well as offal from the canning process, are conveyed to the reduction plants. Briefly the process of reduction is as follows: The fish are



run through a press which extracts the oil. The residue is coarsely chopped and run through a drier where it crumbles into small pieces. This mass then passes over a magnet before going into a grinder. By this means, the tag only and not the fish is recovered.

In all localities in California, magnets are supplied by the California Division of Fish and Game and installed by the reduction plants, except in the case of a few plants which operate private magnets to keep metal scrap out of their grinders. The magnets pick up unbelievable quantities of metal such as nails, bolts, fish hooks and broken pieces of machinery, which somehow find their way into the reduction pit. Consequently careful sorting is necessary to find all of the tags which may have collected on a magnet. Usually scrap from magnets is sorted for tags by an employee of the Division of Fish and Game, but occasionally the reduction plant employees do this.

The number of tags recovered by this system of magnets in the meal lines is dependent not only on the number of magnets in operation but on their efficiency. Many tons of sardines are used for canning rather than reduction. During conveyance of offal from the cannery to the reduction plant a large proportion of the tags are lost. On the other hand, about 90 per cent of the tags in fish going direct to the reduction plant are picked up by the magnets. Consequently, plants running straight reduction can be expected to pick up more tags than combined canning and reduction plants for each ton of fish received.

In so far as funds have allowed, magnets have been placed in all reduction plants where their installation is mechanically possible. During the 1936-1937 sardine season magnets were installed in less than one-half of the California plants, and not all of the magnets were in operation throughout the entire season. Because of these complicating factors, it has not been possible to calculate accurately the percentage of sardine meal which passed over magnets but it probably did not exceed one-third during the 1936-1937 sardine season. The number of tags recovered is presumably considerably less, therefore, than the total number of tagged fish taken by the fishermen.

Thus, our sardine tagging program will meet with greater success as we are able to increase the efficiency of our recovery methods. At least eighteen more magnets will be installed before the 1937-1938 season, but further improvements would be desirable. Although we can trace movements of tagged fish from one region to another, our present method is not efficient enough to yield reliable data on which to calculate fishing intensity and size of the sardine population. Also, as fish from many boats are often unloaded into one reduction pit, it is impossible to determine from which boat a tag may have come. Consequently, it is not possible to tell in which locality within a fishing region the fish bearing the tag may have been caught. To meet these problems in its herring investigation the United States Bureau of Fisheries has devised an electronic detector (Dahlgren, 1936). This instrument makes possible the recovery of the fish bearing the tag at the time that a boat is being unloaded, and as a result the locality in which the fish was caught can be ascertained. The cost of installing and operating this detector prohibits its use in all our California plants but the addition of two or three as a supplement to our present magnets would furnish

additional information essential for a more thorough understanding of the sardine population.

### Tagging and Recovery by Regions

For convenience in discussing tagging and recoveries, the California coastline has been divided into fishing regions (see figure 24). Because the San Francisco and Monterey fishing grounds overlap, they have been combined into one region for the purpose of this discussion. San Francisco boats fish from Pt. Arena southward to Monterey Bay whereas Monterey boats fish from Pt. Reyes to Pt. Sur. The San Pedro region is considered as covering the area from Pt. Conception to Oceanside. Although San Pedro fishermen do occasionally make catches below Oceanside, the occurrence is so rare that it can be almost disregarded. The San Diego region extends from Oceanside southward to the Coronado Islands. A few fish have been tagged in Lower California waters.

#### *San Francisco-Monterey Region.*

As shown in table 1, a total of 8,222 sardines has been tagged in the San Francisco-Monterey fishing region. However, all of these fish, except 593 tagged in Halfmoon Bay, were released in Monterey Bay. This may account for the greater recovery of these fish at Monterey than at San Francisco. Recovery of only 16 of these tags, 4 at San Francisco and 12 at Monterey, is disappointing when compared with recoveries of tagged fish in other regions (see tables 1 and 2).

We have some evidence to show, although not conclusively as yet, that a far better percentage recovery may be expected from the first four hundred fish tagged in any one group. Apparently, confinement for a longer period of time is a determining factor. During the past season, due to a combination of unfavorable conditions, the northern fish were often not tagged until daylight. In the south, where far better recoveries have been obtained, the sardines have always been tagged soon after being caught. In the San Francisco-Monterey region sardines were tagged from a live car whereas in the southern regions the fish were tagged from a live box on board a speed boat. It took longer to tow the live car than to run the speed boat to shelter where tagging could be performed. This also added to the length of time the fish were held. It therefore seems advisable to improve the technique considerably in the San Francisco-Monterey region.

The canneries and reduction plants in the San Francisco Bay area are scattered along the Bay and Sacramento River from San Francisco to Pittsburg. Tags recovered in any of these reduction plants are listed as being recovered at San Francisco. Disregarding the floating reduction fleet, which operated beyond the three-mile limit, there were 18 plants operating in this region during all or part of the 1936-1937 sardine season. Seven of these plants were equipped with magnets for the recovery of tags. Practically all meal from the San Francisco floating reduction fleet is ground in one plant at San Francisco. This plant is equipped with its own magnet which has accounted for most of the 23 California tags and the 2 British Columbia tags recovered in this locality.



Of the 17 canneries and reduction plants situated on Monterey Bay, all but one are located near the town of Monterey. Magnets serving seven plants in this locality have accounted for 32 tags.

### *San Pedro Region.*

In the San Pedro region, 14,715 sardines have been tagged. Although a great many were released toward the end of the season, and a few after the close, from which no recoveries can be expected as yet, there have been 246 returns. San Pedro tags have been recovered in all localities in California where magnets are installed (see tables 1 and 2). From 964 fish tagged in Santa Monica Bay during March and April, 1936, there have been 53 recoveries, as follows: 19 at San Francisco, 20 at Monterey and 14 at San Pedro (see table 2).

TABLE 2

California Sardine Tag Recoveries, 1936-1937 Season

| Sardines tagged by locality |                                   |                           |                            | Number of recoveries by region |                       |                        |                        | I                                              | J                                            |
|-----------------------------|-----------------------------------|---------------------------|----------------------------|--------------------------------|-----------------------|------------------------|------------------------|------------------------------------------------|----------------------------------------------|
| A                           | B                                 | C                         | D                          | E                              | F                     | G                      | H                      |                                                |                                              |
| Date tagged                 | Locality tagged                   | Number of sardines tagged | Percentage of total tagged | Recovered at San Francisco     | Recovered at Monterey | Recovered at San Pedro | Recovered at San Diego | Total number recovered from each day's tagging | Percentage recovered from each day's tagging |
|                             |                                   |                           | 100 C<br>M C               |                                |                       |                        |                        |                                                | 100 I<br>C                                   |
| 3/ 9/36                     | Santa Monica Bay                  | 881                       | 3.49                       | 18                             | 19                    | 13                     |                        | 50                                             | 5.68                                         |
| 4/28/36                     | Santa Monica Bay                  | 83                        | 0.33                       | 1                              | 1                     | 1                      |                        | 3                                              | 3.61                                         |
| 9/16/36                     | Monterey Bay                      | 1,496                     | 5.94                       | 3                              | 7                     |                        |                        | 10                                             | 0.67                                         |
| 9/23/36                     | Monterey Bay                      | 80                        | 0.32                       |                                |                       |                        |                        |                                                |                                              |
| 9/24/36                     | Monterey Bay                      | 796                       | 3.16                       |                                |                       |                        |                        |                                                |                                              |
| 9/25/36                     | Monterey Bay                      | 749                       | 2.97                       | 1                              | 2                     |                        |                        | 3                                              | 0.40                                         |
| 10/14/36                    | Monterey Bay                      | 897                       | 3.56                       |                                | 3                     |                        |                        | 3                                              | 0.33                                         |
| 10/15/36                    | Monterey Bay                      | 1,337                     | 5.30                       |                                |                       |                        |                        |                                                |                                              |
| 11/19/36                    | Santa Monica Bay                  | 990                       | 3.93                       |                                |                       | 21                     | 1                      | 22                                             | 2.22                                         |
| 11/20/36                    | Santa Monica Bay                  | 683                       | 2.71                       |                                |                       |                        |                        | 9                                              | 1.32                                         |
| 12/17/36                    | Half Moon Bay                     | 593                       | 2.35                       |                                |                       | 9                      |                        |                                                |                                              |
| 1/14/37                     | Monterey Bay                      | 197                       | 0.78                       |                                |                       |                        |                        |                                                |                                              |
| 1/15/37                     | Monterey Bay                      | 988                       | 3.92                       |                                |                       |                        |                        |                                                |                                              |
| 1/16/37                     | Monterey Bay                      | 1,089                     | 4.32                       |                                |                       |                        |                        |                                                |                                              |
| 1/23/37                     | Los Angeles Harbor                | 501                       | 1.99                       |                                |                       | 1                      |                        | 1                                              | 0.20                                         |
| 2/ 1/37                     | Newport                           | 489                       | 1.94                       |                                |                       | 9                      |                        | 9                                              | 1.84                                         |
| 2/ 2/37                     | Newport                           | 479                       | 1.90                       |                                |                       | 3                      |                        | 3                                              | 0.63                                         |
| 2/ 3/37                     | Newport                           | 1,148                     | 4.55                       |                                |                       | 23                     | 5                      | 28                                             | 2.44                                         |
| 2/ 4/37                     | Newport                           | 1,104                     | 4.38                       |                                |                       | 9                      | 1                      | 10                                             | 0.91                                         |
| 2/19/37                     | Newport                           | 195                       | 0.77                       |                                |                       | 9                      |                        | 9                                              | 4.62                                         |
| 2/20/37                     | Newport                           | 475                       | 1.89                       |                                |                       | 8                      |                        | 8                                              | 1.68                                         |
| 2/23/37                     | Newport                           | 423                       | 1.68                       |                                |                       | 6                      |                        | 6                                              | 1.42                                         |
| 3/ 2/37                     | Newport                           | 795                       | 3.16                       |                                |                       | 19                     | 1                      | 20                                             | 2.52                                         |
| 3/ 3/37                     | From La Jolla to Oceanside        | 574                       | 2.28                       |                                |                       | 17                     | 4                      | 21                                             | 3.66                                         |
| 3/ 9/37                     | Coronado                          | 830                       | 3.29                       |                                |                       | 15                     | 1                      | 16                                             | 1.93                                         |
| 3/10/37                     | San Diego Bay                     | 773                       | 3.07                       |                                |                       | 1                      |                        | 1                                              | 0.13                                         |
| 3/17/37                     | Newport                           | 396                       | 1.57                       |                                |                       |                        |                        |                                                |                                              |
| 3/19/37                     | Newport                           | 630                       | 2.50                       |                                |                       | 6                      |                        | 6                                              | 0.95                                         |
| 3/23/37                     | Newport                           | 1,582                     | 6.28                       |                                |                       | 19                     |                        | 19                                             | 1.20                                         |
| 3/24/37                     | Newport                           | 1,597                     | 6.33                       |                                |                       | 17                     |                        | 17                                             | 1.06                                         |
| 3/26/37                     | Newport                           | 797                       | 3.16                       |                                |                       | 22                     |                        | 22                                             | 2.76                                         |
| 3/27/37                     | Newport                           | 680                       | 2.70                       |                                |                       | 3                      |                        | 3                                              | 0.44                                         |
| 4/20/37                     | San Quentin Bay, Lower California | 91                        | 0.36                       |                                |                       |                        |                        |                                                |                                              |
| 5/ 9/37                     | Long Beach                        | 787                       | 3.12                       |                                |                       |                        |                        |                                                |                                              |
|                             | Totals                            | 25,205                    | 100.00                     | 23                             | 32                    | *231                   | 13                     | *299                                           |                                              |

\* Three broken tags recovered at San Pedro are not included in these totals.

On one occasion it was necessary to bring a live box full of fish to Balboa where tagging was performed  $1\frac{1}{2}$  miles within Newport Harbor. Recovery of several of these tags two days later indicated that the fish had little or no difficulty finding their way down the narrow channel to the open sea, as there is no sardine fishing within the harbor entrance. Further tagging at the same place with subsequent recoveries within a short period has confirmed this conclusion.

Tags found in canneries and reduction plants in the Los Angeles Harbor area are referred to as San Pedro recoveries even though they may be from plants located in Wilmington or Long Beach. Nine of the 14 plants in this area are provided with magnets and have recovered 234 California tags and 3 British Columbia tags.

### *San Diego Region.*

In the San Diego region, 2,177 sardines have been tagged, with subsequent recovery of 33 tags at San Pedro and 5 tags at San Diego. The small number of these tags recovered at San Diego—compared with tags from the same group recovered at San Pedro—is accounted for by the fact that most of these fish were tagged during the last two days that appreciable amounts of sardines were taken by fishermen operating in this region although fishing continued in the San Pedro region.

It is of interest to note that from 574 fish, most of which were tagged and released one by one while the boat cruised from La Jolla to a point two miles off Oceanside, 21 recoveries have been made (see table 2). At no other time were sardines tagged under way.

On San Diego Bay, magnets are installed in three of the four reduction plants operating in that area. These have accounted for 13 tags.

### *Lower California.*

In April, 1937, 91 sardines were tagged in San Quentin Bay, 170 miles south of San Diego. They were obtained from the bait tanks of a small tuna clipper. As most of them were very small it is doubtful if many survived marking. Larger fish could not be found at the time.

## **Acknowledgments**

Without the wholehearted cooperation extended to the State Fisheries Laboratory of the California Division of Fish and Game by those engaged in the fishing industry, the sardine tagging program could not have progressed successfully. We therefore wish to express our appreciation to those who have had a part, especially to the fishermen who have ever been willing to donate sardines in spite of inconveniences, and to the owners and employees of the canneries and reduction plants who have cooperated to the fullest extent. We are indebted to the Bureau of Patrol of the Division for the use of their patrol boats "Albacore" and "Yellowtail," to the captains of these vessels, Lars Weseth and Edward R. Hyde, for their valuable suggestions and untiring efforts, and to the boat crews for their willingness and assistance. It is a pleasure to acknowledge the cooperation on the part of the Canadian authorities who have exchanged tagging data with us and searched for California tags on magnets installed in British Columbia. Every member on the staff of the State Fisheries Laboratory has taken



an active part not only in the actual tagging of fish and searching for recoveries in the metal scrap collected by the magnets, but in formulating plans and methods.

TABLE 3

Summary of Sardines Tagged by the California State Fisheries Laboratory, March 9, 1936 to May 10, 1937

| Tag number  | Number tagged | Date tagged    | Locality tagged and released <sup>1</sup>                                                                           |
|-------------|---------------|----------------|---------------------------------------------------------------------------------------------------------------------|
| 101- 999    | 881           | Mar. 9, 1936   | Santa Monica Bay<br>Released: Pt. Dume Cove                                                                         |
| 1000- 1099  | 83            | Apr. 29, 1936  | Santa Monica Bay<br>Released: Between Santa Monica and Topango                                                      |
| 1100- 2599  | 1,496         | Sept. 16, 1936 | Monterey Bay<br>Released: Capitola Harbor                                                                           |
| 2600- 2699  | 80            | Sept. 23, 1936 | Monterey Bay<br>Released: One mile off Capitola                                                                     |
| 2700- 3499  | 796           | Sept. 24, 1936 | Monterey Bay<br>Released: One mile off Sequel Pt. (between Santa Cruz and Capitola)                                 |
| 3500- 4249  | 749           | Sept. 25, 1936 | Monterey Bay<br>Released: Between Monterey and Del Monte                                                            |
| 4250- 5149  | 897           | Oct. 14, 1936  | Monterey Bay<br>Released: Santa Cruz Harbor                                                                         |
| 5150- 6499  | 1,337         | Oct. 15, 1936  | Monterey Bay<br>Released: Santa Cruz Harbor                                                                         |
| 6500- 7499  | 990           | Nov. 19, 1936  | Santa Monica Bay<br>Released: One mile off Ocean Park                                                               |
| 7500- 7999  | 496           | Nov. 20, 1936  | Santa Monica Bay<br>Released: Half mile off Malibu                                                                  |
| 8200- 8399  | 187           | Nov. 20, 1936  | Santa Monica Bay<br>Released: Half mile off Malibu                                                                  |
| 8400- 8999  | 593           | Dec. 17, 1936  | Half Moon Bay                                                                                                       |
| 9000- 9199  | 197           | Jan. 14, 1937  | Monterey Bay<br>Released: Between Monterey and Del Monte                                                            |
| 9200-10199  | 988           | Jan. 15, 1937  | Monterey Bay<br>Released: Between Monterey and Del Monte                                                            |
| 10200-11299 | 1,089         | Jan. 16, 1937  | Monterey Bay<br>Released: Between Monterey and Del Monte                                                            |
| 12000-12499 | 501           | Jan. 23, 1937  | San Pedro<br>Released: Half mile off Cabrillo Beach                                                                 |
| 12500-12982 | 489           | Feb. 1, 1937   | Newport Harbor<br>Released: Quarter mile inside entrance to harbor                                                  |
| 12983-13449 | 479           | Feb. 2, 1937   | Newport Harbor<br>Released: Quarter mile inside entrance to harbor                                                  |
| 13450-14599 | 1,148         | Feb. 3, 1937   | Newport Harbor<br>Released: Quarter mile inside entrance to harbor                                                  |
| 14600-14999 | 401           | Feb. 4, 1937   | Newport Harbor<br>Released: Quarter mile inside entrance to harbor                                                  |
| 18000-18699 | 703           | Feb. 4, 1937   | Newport Harbor<br>Released: Quarter mile inside entrance to harbor                                                  |
| 18700-18895 | 195           | Feb. 19, 1937  | Newport Harbor<br>Released: Quarter mile inside entrance to harbor                                                  |
| 18900-19374 | 475           | Feb. 20, 1937  | Newport Harbor<br>Released: Quarter mile inside entrance to harbor                                                  |
| 19375-19799 | 423           | Feb. 23, 1937  | Newport Harbor<br>First 69 released at entrance to harbor. Last 354 released quarter mile inside entrance to harbor |
| 19800-20599 | 795           | Mar. 2, 1937   | Newport Harbor<br>Released: Quarter mile inside entrance to harbor                                                  |
| 20600-21150 | 574           | Mar. 3, 1937   | First 200 released quarter mile off La Jolla; rest released while under way between La Jolla and Oceanside          |
| 21152-21999 | 830           | Mar. 9, 1937   | Coronado<br>Released: Two miles south of Coronado                                                                   |
| 22000-22775 | 773           | Mar. 10, 1937  | San Diego Bay<br>Released: Under Ballast Pt. one-eighth mile from shore                                             |
| 22776-23166 | 396           | Mar. 17, 1937  | Newport Harbor<br>Released: Balboa Pavilion                                                                         |
| 23167-23799 | 630           | Mar. 19, 1937  | Newport Harbor<br>Released: Balboa Pavilion                                                                         |
| 23800-24568 | 756           | Mar. 23, 1937  | Newport Harbor<br>Released: Balboa Pavilion                                                                         |
| 24569-25399 | 826           | Mar. 23, 1937  | Newport Harbor<br>Released: One eighth mile inside entrance to harbor                                               |
| 25400-26999 | 1,597         | Mar. 24, 1937  | Newport Harbor<br>Released: Balboa Pavilion                                                                         |
| 27000-27659 | 659           | Mar. 26, 1937  | Newport Harbor<br>Released: Quarter mile inside entrance to harbor                                                  |
| 27760-27899 | 138           | Mar. 26, 1937  | Newport Harbor<br>Released: Quarter mile inside entrance to harbor                                                  |
| 27900-28499 | 596           | Mar. 27, 1937  | Newport Harbor<br>Released: Quarter mile inside entrance to harbor                                                  |

TABLE 3—Continued

Summary of Sardines Tagged by the California State Fisheries Laboratory,  
March 9, 1936 to May 10, 1937—Continued

| Tag number                 | Number tagged <sup>1</sup> | Date tagged   | Locality tagged and released <sup>2</sup>                                                     |
|----------------------------|----------------------------|---------------|-----------------------------------------------------------------------------------------------|
| 29850-29933                | 84                         | Mar. 27, 1937 | Newport Harbor<br>Released: Quarter mile inside entrance to harbor                            |
| 28600-28692                | 91                         | Apr. 20, 1937 | San Quentin Bay, Lower California<br>Released: One mile from shore at northeast side of bay * |
| 28514-28599<br>28693-28999 | 389                        | May 9, 1937   | Long Beach<br>Released: Half mile off Belmont Shore                                           |
| 29000-29399                | 398                        | May 9, 1937   | Long Beach<br>Released: Half mile off Alamitos Bay                                            |

<sup>1</sup> Due to imperfections in the numbering machine, there were a few scattered duplicate tags which were sometimes used. On the other hand, the machine occasionally skipped numbers and furthermore, a few tags were lost. Occasionally mackerel were found with the sardines and tagged with the internal tags. This explains any apparent discrepancy in the number of fish tagged in any series.

<sup>2</sup> Localities given in this table are shown in figure 24, with the exception of San Quentin Bay, Lower California.

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## TROUT AND SALMON MARKING IN CALIFORNIA <sup>1</sup>

By Leo Shapovalov

*Bureau of Fish Conservation*

*California Division of Fish and Game*

Each year millions of young trout and salmon are reared in the 25 hatcheries maintained by the California Division of Fish and Game and are planted in public waters throughout the State. Later many of these fish are caught in the streams and lakes and some of the salmon are taken at sea. But what percentage of the planted fish survive to be caught by fishermen? What percentage of the fish caught are hatchery-reared and what percentage the result of natural propagation? Where do the planted fish go? At what size, in what number, and in which streams should the different species of trout and salmon be released? Only by gaining some knowledge concerning these questions can the rational management of our streams and lakes be carried out and the sportsman and the commercial fisherman be assured of maximum return on their time and investment.

In order to help answer these questions the Bureau of Fish Conservation of the California Division of Fish and Game each year marks a large number of trout and salmon at several hatcheries and liberates them in various bodies of water. King (chinook, quinnat) and silver (coho) salmon and steelhead trout have all been marked and liberated as young fish in the Klamath River, in several smaller coastal streams in central California, and in the Truckee River. Some of these fish swim to far distant points, as in the case of several silver salmon that were marked in Waddell Creek, below San Francisco Bay, and recovered off Ft. Bragg, 250 miles away.

In all marking it is hoped that as many as possible of the marked fish will be recovered at a later date and can then be identified by their marks and examined. Two methods of marking fish are used in the State: one by attaching some sort of numbered tag, the other by clipping off certain combinations of fins. Tagging is employed when it is desirable to secure returns on *individual* fish, as in studying the egg production of fish returning during successive years to an egg-taking station. The sex, size and age of the fish being tagged are usually determined in such cases. Marking by clipping off certain combinations of fins is employed when it is desired to get returns only for a *group* of fish, such as a particular plant from a hatchery or a certain age group (year class) of naturally propagated fish. In such cases ordinarily the size and age of only the group, i.e., the average size, is known.

The securing of returns in coastal streams is greatly aided by the strongly developed tendency of both adult trout and salmon at sea to return to spawn in the stream which they left as young fish. This is known as homing. Some of the marked fish are planted in streams at

<sup>1</sup> Submitted for publication June, 1937.

which the Division maintains egg-taking stations, with the expectation that they will be recovered at these stations. However, many of the marked fish are caught by anglers and by commercial fishermen at sea. And it is in such cases that these men can greatly aid conservation and help to assure good fishing for themselves in future years by supplying the information outlined below.

In figure 31 the fins which are used in marking are shown in black; any two or three of these fins may be clipped off in marking a certain lot of fish. It is requested that anyone who catches or handles one of these fish record:

1. *Species*
2. *Sex*
3. *Date and place where caught*
4. *How fish is marked—what fins are lacking*
5. *Length in inches and quarter-inches*
6. *Weight in pounds and quarter-pounds*

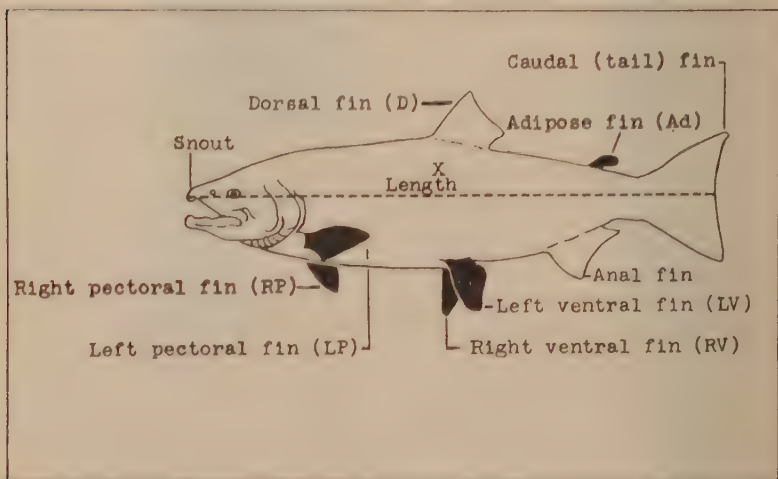


FIG. 31. Diagram showing the fins that are removed in marking trout and salmon. The abbreviations in parentheses are those used in the accompanying tables of markings.

The informant should also scrape about 30 or 40 scales from the side of the fish below the dorsal fin (from area shown by X in fig. 31) and cut out the scars where each fin was removed and place these in salt in an envelope. He should then write plainly the information asked for and his own name and address on the outside of the envelope, place it in a larger envelope, and mail to the California Division of Fish and Game, Stanford University, California, or give to any employee of the Division.

It is again emphasized that by recording their marked fish fully and accurately anglers and commercial fishermen will help the Division study the habits and migrations of the salmon and trout, and through this study to maintain the supply of these fishes.

Each person sending in a record of a marked fish will be sent a card telling where and when his fish was hatched and liberated.

The following is a record of trout and salmon marked in California during the past several years. Returns from these plants will be described at a later date.

## WADDELL CREEK, SANTA CRUZ COUNTY

| Year          | Steelhead         | Silver Salmon |
|---------------|-------------------|---------------|
| 1931 .....    | 924 Ad-LV .....   | 1268 Ad-LV    |
| 1932 .....    | No marking .....  | No marking    |
| 1933-34 ..... | 2452 Ad-RP .....  | 3202 Ad-RP    |
| 1934-35 ..... | 1013 Ad-LP .....  | 3481 Ad-LP    |
| 1935-36 ..... | 3118 Both P ..... | 4392 Both P   |
| 1936-37 ..... | 2745 Ad-RP .....  | 1067 Ad-RP    |

## SCOTT CREEK, SANTA CRUZ COUNTY

| Year                       | Species             | Number | Mark                          | No. per oz. | Remarks                 |
|----------------------------|---------------------|--------|-------------------------------|-------------|-------------------------|
| 1932-33 (Jan. 11-18) ..... | Steelhead .....     | 9,826  | Ad-RV .....                   | (109 mm.)   | Planted in upper lagoon |
| 1932-33 (Jan. 19) .....    | Steelhead .....     | 1,177  | Ad only .....                 | (130 mm.)   | Planted in upper lagoon |
| 1932-33 (Feb. 3) .....     | Silver Salmon ..... | 942    | Ad-LV .....                   | (Yearlings) |                         |
| 1933-34 (Jan. 11-15) ..... | Steelhead .....     | 10,054 | Both V .....                  | 3.2         |                         |
| 1934-35 (Feb. 11-12) ..... | Steelhead .....     | 5,605  | Ad-LV .....                   | 1.12        |                         |
| 1935-36 (Jan. 24) .....    | Steelhead .....     | 10,030 | Ad-RV .....                   | 5.66        |                         |
| 1935-36 (Jan. 29) .....    | Steelhead .....     | 2,240  | Ad-Ant. $\frac{1}{2}$ D ..... | 2.18        | Grisle offspring        |
| 1935-36 (June 25) .....    | Steelhead .....     | 16,659 | Both V .....                  | 23.1        | Marked fish offspring   |
| 1936-37 (July 9) .....     | Silver Salmon ..... | 5,860  | Both V .....                  | 8.20        |                         |
| 1936-37 (July 9) .....     | Silver Salmon ..... | 4,848  | Both P .....                  | 8.20        |                         |
| 1936-37 (July 14-15) ..... | Silver Salmon ..... | 5,673  | Ad-LV .....                   | 7.43        |                         |

## TRUCKEE RIVER, NEVADA COUNTY

| Year | Species                   | Number | Mark         | Remarks     |
|------|---------------------------|--------|--------------|-------------|
| 1932 | Steelhead .....           | 20,155 | Ad-RV .....  | Klamath lot |
| 1932 | Steelhead (Rainbow) ..... | 20,141 | Ad-LV .....  | Idaho lot   |
|      | Total .....               | 40,296 |              |             |
| 1933 | Steelhead .....           | 41,070 | Both V ..... |             |

## KLAMATH RIVER, SISKIYOU COUNTY

| Year                   | Species           | Number | Mark            | No. per oz. | Remarks                           |
|------------------------|-------------------|--------|-----------------|-------------|-----------------------------------|
| 1934 (May 10-16) ..... | Steelhead .....   | 23,280 | Ad-RV .....     | 5.4         | Beaver Cr. lot—Planted Beaver Cr. |
| 1934 (May 10-16) ..... | Steelhead .....   | 12,650 | Ad-LV .....     | 4.5         | Camp Cr. lot—Planted Fall Cr.     |
| 1934 (May 10-16) ..... | Steelhead .....   | 9,774  | Ad-Both V ..... | 8.4         | Kosk Cr. lot—Planted Fall Cr.     |
| 1935 (May 9-13) .....  | Steelhead .....   | 29,591 | Both V .....    | 9.1         | Planted W. Fk. Beaver Cr.         |
| 1936 (June 5, 8) ..... | Steelhead .....   | 24,694 | Ad-LV .....     | 2.59        | Planted W. Fk. Beaver Cr.         |
| 1936 (June 29) .....   | Steelhead .....   | 2,684  | Ad-LV .....     | 2.1         | Planted W. Fk. Beaver Cr.         |
| 1935 (Sept. 3) .....   | King Salmon ..... | 38,170 | Both V .....    | 4.          | Spring run fish—Planted Fall Cr.  |
| 1936 (Aug. 15) .....   | King Salmon ..... | 39,170 | Ad-RV .....     | 5.7         | Spring run fish—Planted Fall Cr.  |
| 1937 (July 31) .....   | King Salmon ..... | 30,236 | Ad-LV .....     | 3.22        | Spring run fish—Planted Fall Cr.  |



## EXPERIMENTS IN HATCHING STEELHEAD EGGS IN GRAVEL<sup>1</sup>

By Leo Shapovalov

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Each year with the arrival of the rainy season, schools of steelhead trout fight their way up the streams of California from the Pacific Ocean and spawn in suitable gravel beds. Some weeks later their progeny emerge from the gravel, and soon millions of these fry are scattered throughout the streams in which the steelhead had spawned. What has taken place during this time? And what happens to so many of these fry, whose ranks are presently decimated to such an extent that even the casual observer can notice their strikingly fewer number?

To answer these questions correctly, we must know such things as the number of temperature units<sup>2</sup> required for the eggs to hatch in the gravel, the number of temperature units required for the hatched fry to work up to the surface of the gravel, the percentage of survival to time of emergence from the gravel of the eggs spawned, the weight and health of naturally hatched as compared with hatchery fish, and their comparative resistance to disease. It is essential that we secure a clear picture of what happens both in artificial and natural propagation before we can make a comparative evaluation of the two.

It was largely with the purpose of securing more light on these factors, of both theoretical and practical interest, and concerning which our information is so meager, that the writer, at the time working with the California Trout Investigation, organized the experiments outlined in the following pages. The problems are stated perhaps more fully than the extent of the present experiments would ordinarily justify for the reason that further experiments may be carried out.

The experiments were conducted at the Big Creek State Fish Hatchery, fourteen miles north of Santa Cruz, California, with eggs secured at the Scott Creek Egg-taking Station, one mile away.

### Experiment No. 1

#### *Method and Procedure.*

At noon on February 6, 1936, the eggs of a steelhead trout, *Salmo gairdnerii*, 75 centimeters in length (to fork of caudal fin), were fertilized in the routine manner at the egg-taking station and then set aside in a glass two-quart jar. These eggs averaged 215 per fluid ounce. Upon becoming water-hardened, they were taken to the hatchery.

<sup>1</sup> Submitted for publication March 30, 1937.

The writer is indebted to Mr. William Berrian, foreman of the Big Creek Hatchery, who kindly kept the daily records of losses and numbers of fish hatching and emerging during the course of the experiments.

<sup>2</sup> One temperature unit (t. u.) equals 1° F. above 32° for a period of 24 hours.

There 1000 of the eggs were counted out and placed in a standard wire hatching basket suspended in a standard hatchery trough with flowing water. These served as a control on the experimental lot of 1000 eggs, which were buried in gravel, using the procedure outlined below. In neither lot were infertile eggs picked out before counting.

A rectangular aquarium with a cement bottom, glass sides, and window-screen in the ends was used and placed in the same trough as the control basket, and just ahead of it. This aquarium was 16 inches long,  $8\frac{1}{2}$  inches wide, and 10 inches deep.

A layer of gravel which had previously been washed free of most of the sand and silt in it by being rolled around in a piece of minnow seine under water was then placed on the bottom of the aquarium. The gravel used came from the creek bed just above the dam at the Scott Creek Egg-taking Station and was selected to simulate the type and size of gravel on which the steelhead ordinarily spawn.

The bottom layer of gravel was approximately one and one-half inches deep. On this were placed 500 of the eggs, which settled into the pockets and crevices of the gravel bed. These were covered by approximately one and one-half inches of gravel, upon which the remaining 500 eggs were placed. The latter were then also covered by a layer of gravel one and one-half inches in depth. Approximately an inch of water now remained over the top of the gravel.

Black metal sheets were placed in front of and behind the aquarium in such a manner as to shut out light at the ends and yet insure a current of water running through the aquarium. The top of the aquarium was covered by a double thickness of window shade, so that it was in total darkness.

This first experiment was directed to: (1) finding out the feasibility of such experiments under existing conditions, (2) making general observations on eggs and alevins while in the gravel, and (3) comparing size and health of the fish from the gravel and in the control. Since this first experiment was more of a general observational experiment, no hesitation was exercised about taking samples and also in leaving the fry over the gravel after their emergence. In this way their behavior could be observed, but it was impossible to record the exact number hatching each day and the exact day of maximum hatch, these being reserved for the second experiment.

Beginning February 10, the fourth day of the experiment, heavy rains caused the water to become extremely and unusually muddy. This muddy water continued for nine days. The exact effect on the eggs in the gravel cannot be told, except by inference from the survival data, but it was observed that there was a heavy coating of silt on top of the gravel and down the sides of the aquarium, reaching the eggs. The effect of these conditions and its application to naturally spawned eggs will be discussed in the summary. It may be significant that in the control lot the largest number of dead eggs was removed during the three days following the period of muddy water.

It was the aim in this initial experiment, then, to simulate natural conditions as closely as possible and yet permit a reasonable degree of observation on the eggs in the gravel.

*Results.*

The eggs in the gravel hatched at approximately the same time as the control eggs. At the time of the first hatch in the control basket, some good and some bad eggs could be seen in the gravel. Apparently a little fungus was present but this could not be made out for certain.

The eggs in the control hatched during a period of four days, with March 7 the day of maximum hatch.

A sample of 41 fish was taken from the control trough on the second day after the eggs had hatched. These fish averaged 17.2 millimeters (0.68 inch) in total length (range 17-18 millimeters) and 0.105 gram (270 fish per ounce) in weight. They were dried on a paper towel for one minute before weighing. Both measurement and weighing were done with the fish preserved.

Feeding was begun in the control lot March 26, at the same time that it was begun in the regular hatchery fish of the same age. The first fish emerged from the gravel in the aquarium on the same day. On the following day one more fish appeared over the gravel and on March 28 two more. On March 29 there was a total of 30, and on March 31 a total of 60. Samples of 50 fish from the aquarium and 49 from the control trough were taken on this last day, and weighed and measured in the same manner as in the previous sample. The fish from the aquarium averaged 24.0 millimeters (0.95 inch) in total length (range 23-26 millimeters) and 0.156 gram (182 fish per ounce) in weight, whereas those from the control lot averaged 25.4 millimeters (one inch) in length (range 25-27 millimeters) and 0.182 gram (172 fish per ounce) in weight.

It is seen that the fish from the control were larger than those from the aquarium. The former fish were very even in size, and the yolk sac made only a slight protuberance. Many of those in the sample from the aquarium had a considerable yolk sac still present, showing a retarded degree of development, but appeared quite healthy and not at all weak. The fact that the fish in the control lot had been fed five days may account at least partially for the difference in size.

The long period over which the fish appeared from the gravel (approximately 16 days) is of interest.

It is also of interest that whereas the fish in the control lot died at the rate of about one fish a day from the time they hatched until April 15, when the experiment was concluded, there was no loss at all in the aquarium fish. So, although the aquarium fish were somewhat smaller than the control fish, their survival rate was better. (The losses in the control trough may have been due to injury in the course of routine trough cleaning.)

Table 1 shows the number of temperature units and the number of days that it took the eggs to reach various stages and also the mean temperature during the various periods. The table also shows the average weight and length of the fish in the different samples taken.

Table 2 shows the survival of the fish in the aquarium and in the control.



TABLE 1

|                                                                        | Date    | Temperature units | Mean temperature for period | Number days for period |
|------------------------------------------------------------------------|---------|-------------------|-----------------------------|------------------------|
| Eggs fertilized                                                        | Feb. 6  | ---               | ---                         | ---                    |
| To eyeing                                                              | Feb. 17 | 188.8             | 49.2° F.                    | 11                     |
| To maximum hatch in control                                            | Mar. 7  | 563.0             | 50.8° F.                    | 30                     |
| Average weight and length control fish (0.105 grams, 17.2 millimeters) | Mar. 10 | 625.0             | 50.9° F.                    | 33                     |
| To first emergence from gravel                                         | Mar. 26 | 936.1             | 51.1° F.                    | 49                     |
| Maximum hatch control to first emergence from gravel                   | Mar. 26 | 373.1             | 51.6° F.                    | 19                     |
| To maximum (?) emergence from gravel                                   | Apr. 10 | 1206.1            | 50.8° F.                    | 64                     |
| Maximum hatch control to maximum (?) emergence from gravel             | Apr. 10 | 643.1             | 50.9° F.                    | 34                     |
| Average weight and length control fish (0.182 grams, 25.4 millimeters) | Mar. 31 | 1025.1            | 51.0° F.                    | 54                     |
| Average weight and length gravel fish (0.156 grams, 24.0 millimeters)  | Mar. 31 | 1025.1            | 51.0° F.                    | 54                     |

TABLE 2

|                                                                    | Gravel        | Control       |
|--------------------------------------------------------------------|---------------|---------------|
| Eggs at start                                                      | 1000          | 1000          |
| Eggs eyed                                                          | ---           | 959 (95.9%)   |
| Eggs hatched                                                       | ---           | 832 (83.2%)   |
| Fish emerging from gravel and fish present in control at same time | 298 (29.8%) * | 800 (80.0%) * |

\* This number includes fish that were used for the samples, since the loss in the aquarium from time of sample to final count was zero and the loss in the control from the time of first sample to time of second sample was only twenty-six, or 3.3%, meaning that probably only one fish of the sample of 41 would have died, and from time of second sample to the count of April 16, the loss was only nine, or 1.2%, meaning that probably only one fish of the sample of 49 would have died. Thus, the probability is that if the sample had not been taken the total number of fish that would have died would have been increased by only two, i.e., that 798 of the 800 fish listed would have survived in the control lot.

## Experiment No. 2

### Method and Procedure.

The procedure followed in the second experiment was essentially the same as that followed in the first. The eggs used in the second experiment were fertilized at 2 p.m. on April 23, 1936.

The only differences in procedure were that instead of the gravel being placed in the aquarium it was placed directly in the trough, and that the eggs were placed at a uniform depth in the gravel. First a layer of gravel was placed directly on the trough, covering the lower half of the trough to a depth of two inches, then 5,000 eggs were scattered over the gravel and were covered by an approximately uniform layer of four inches of gravel. A perforated plate was placed in front of the gravel to force water to run through it. The control consisted of 1,000 eggs from the same fish placed in a basket in the adjoining trough.

It is seen that in the second experiment no attempt was made at observation of the eggs and fish in the gravel. The experiment was largely directed to: (1) checking on the number of temperature units required for the hatched fish to work up to the surface of the gravel, removing the fry daily as they emerged, and thus securing the period of maximum hatch, and (2) checking on the percentage of survival to time of emergence from the gravel of the eggs spawned.

### Results.

The eggs in the control hatched during a period of three days, May 17-19, with May 18 as the day of maximum hatch.

The day of initial emergence of fry from the gravel was May 31, when twenty appeared. The emerging fry were removed to a standard hatchery trough without gravel each day, so that an accurate check on the numbers emerging from the gravel could be kept. Maximum emergence occurred on the ninth day, when 675 fry appeared. The number gradually decreased from that figure. The total period of emergence covered twenty days. This long period of emergence checks well with the period of emergence in the first experiment, which was approximately sixteen days.

The fish as they emerged from the gravel in the second experiment, unlike those in the first, had the yolk sac almost entirely absorbed. This is probably due to the fact that all the eggs were buried deeper in the gravel than any of those in the first experiment.

Table 3 shows the number of temperature units and the number of days that it took the eggs to reach various stages and also mean temperatures during the various periods. Table 4 shows the survival of the fish from the gravel and those in the control.

On June 25, the sixth day after the last fish had emerged from the gravel, all of the fish hatched from the gravel weighed 52 ounces, or 75.9 fish per ounce (live weight). On the same date, all of the fish in the control weighed 62 fish per ounce (live weight). Factors to take into account in considering the difference in size between the two groups are the following: (1) there were approximately one-fifth as many fish in the control trough as in the other; (2) the fish most recently emerged from the gravel were considerably smaller than those which had emerged earlier in the long emergence period, lowering the average size. The control fish, on the other hand, were fairly uniform in size.

TABLE 3

|                                                        | Date    | Temperature units | Mean temperature for period | Number days for period |
|--------------------------------------------------------|---------|-------------------|-----------------------------|------------------------|
| Eggs fertilized                                        | Apr. 23 | ---               | ---                         | ---                    |
| To maximum hatch in control                            | May 18  | 585.5             | 55.4° F.                    | 25                     |
| To first emergence from gravel                         | May 31  | 884.9             | 55.3° F.                    | 38                     |
| Maximum hatch control to first emergence from gravel   | May 31  | 309.4             | 55.8° F.                    | 13                     |
| To maximum emergence from gravel                       | June 8  | 1074.6            | 55.4° F.                    | 46                     |
| Maximum hatch control to maximum emergence from gravel | June 8  | 499.1             | 55.8° F.                    | 21                     |

TABLE 4

|                                                                    | Gravel       | Control     |
|--------------------------------------------------------------------|--------------|-------------|
| Eggs at start                                                      | 5000         | 1000        |
| Eggs hatched                                                       | ---          | 886 (88.6%) |
| Fish emerging from gravel and fish present in control at same time | 3997 (79.9%) | 817 (81.7%) |

### *Subsequent Growth of Fish Hatched from the Gravel When Placed Over Gravel and in a Plain Trough.*

On June 25, the entire 52 ounces of fish that had been hatched from the gravel in the second experiment were split into two lots of 26 ounces each. One lot was placed in a trough over gravel and the other in an adjoining plain trough.

There was subsequently a heavy loss of fish in each of these troughs, due to fungus, which may have been caused by handling the fish in weighing and transferring them to the troughs.

Both of these lots were fed quite sparingly. The plain trough was cleaned in the routine manner, while waste in the graveled trough was removed only in a very superficial manner.

On August 31, after over two months in these troughs, the fish in each trough weighed almost exactly the same. The trout in the plain trough totaled 55 ounces and averaged 17.7 per ounce, while those in the graveled trough totaled 54.5 ounces or 17.1 per ounce. The survival rates of the two lots had therefore been much the same.

There was a fair amount of decayed and old food and waste in the gravel but the fish in the trough did not seem to be adversely affected by this factor.

### Summary and Conclusions

The purpose of the experiments was to determine at least partially the effectiveness of natural spawning of steelhead trout, *Salmo gairdnerii*, by simulation of natural conditions, and to discover what happens from the time the eggs are deposited in the gravel to their emergence from the gravel as fry.

1. In each of two experiments eggs from one adult sea-run fish were split into two lots, one of which was placed in gravel and the other in a standard hatching basket as a control.

2. In the first experiment the buried eggs were placed at depths of one and one-half inches and three inches, respectively, in a glass aquarium screened at the ends and shielded from light. In the second experiment the buried eggs were placed at a uniform depth of four inches, in a hatchery trough.

3. In the first experiment the eggs in the gravel hatched at approximately the same time as the control eggs. (The eggs in the gravel could not be seen in the second experiment.) Fish in the control trough averaged 17.2 millimeters in total length and 0.105 grams in weight, on the second day after hatching (625.0 t. u.).

4. The eggs required 563.0 to 585.5 t. u. to maximum hatch and 1074.6 to 1206.1 t. u. to maximum emergence from gravel (884.9 t. u. to earliest emergence from gravel). The number of temperature units to hatch compares favorably with that obtained for steelhead trout at the Big Creek Hatchery in 1932 by A. C. Taft and J. H. Wales, which was 566.7.

5. Sixteen to 20 days were required from initial to final emergence of fry from the gravel in the two experiments.

6. In the first experiment the fry from the gravel averaged 24.0 millimeters in total length and 0.156 grams in weight, 5 days after initial emergence from the gravel, while the control fish averaged 25.4 millimeters in length and 0.182 grams in weight at the same time. Thus, the trough fish were larger than those from the gravel; this is contrary to results obtained in Holland with Atlantic salmon, *Salmo salar* (B. Havinga, unpublished communication) and in British Columbia with sockeye salmon, *Oncorhynchus nerka* (Robertson, 1919). The smaller size of the aquarium fish may have been caused by premature



emergence, caused in turn by too shallow burial. Fry from eggs in the second experiment, deeper buried, had the yolk sac almost entirely absorbed. Premature emergence caused by shallow burial is cited by Babcock (1911) for Pacific salmon, *Oncorhynchus*. However, in the second experiment the gravel fish were also smaller than the control fish. Factors to take into account in connection with this were cited under "results" of the second experiment.

7. Though larger, the control fish died at the rate of approximately one a day in the first experiment, whereas there was no loss in the aquarium fish after emergence.

8. In the first experiment 83.2 per cent of the control eggs hatched and 80.0 per cent survived to the time that all the fish (29.8 per cent of eggs buried) from the gravel had finished emerging. In the second experiment 88.6 per cent of the control eggs hatched and 81.7 per cent survived to the time that all the fish (79.9 per cent) from the gravel had finished emerging. It is believed that in the above experiments natural (stream) conditions were simulated reasonably well. Granting this, it follows that in nature the percentage of deposited eggs which emerge from the gravel as fry may vary widely. It may be quite low (29.8 per cent) under adverse conditions (silting, caused by flood, as here, or mining) and on the other hand quite high (79.9 per cent) under good conditions. Some authors believe that under natural conditions poor fertilization occurs, and that but a small percentage of the eggs deposited become fish, but the present writer is inclined to believe, on the basis of field observations and the present experiments, that the percentage of eggs which are fertilized, hatch, and emerge from the gravel is rather high and that the heaviest losses occur during the fry stage.

9. Equal lots of the fish hatched from the gravel in the second experiment were divided between a trough containing gravel and one without gravel. After over two months in these troughs the fish from the two environments averaged approximately the same in growth and survival rate.

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## FISHWAYS

*By John Spencer*<sup>1</sup>

Prior to the development of the country and the utilization of the waters of the streams for man's benefit the fish were in practically undisputed possession of these waters and were free to proceed upstream as they desired, except where hindered or stopped by natural falls in the stream. As an aid in the utilization of the waters of the stream, dams were constructed and at first there was little or no attempt to aid fish in passing these barriers. This disregard for the need of fish, especially anadromous species, to proceed to the headwaters of the stream or to suitable stream beds for spawning purposes, resulted in the destruction of certain species and largely contributed to the depletion of others.

While the dams first constructed were generally low in height as compared to present structures, yet they frequently formed an impassible barrier to upward moving fish. As the water resources were increasingly utilized and developed, larger and higher dams were built, resulting in still greater detrimental effect on fish movement and life.

The damage to fish life by the construction of these dams could, in part, be overcome by the installation of fishways. Closely following early dam construction, laws were enacted which required the addition of these structures so that fish would not be prevented from proceeding to the spawning grounds.

A fishway (also called a fish ladder) is an auxiliary structure attached to or around a dam, which permits fish to pass by easy stages from near the downstream toe of the dam to the retained waters above. It may also be used for easy descent by the fish in their downstream journey, but the primary purpose is as above stated.

Fishways have been in use in this and other countries for many years. Some installations may be classed as satisfactory, or nearly so, but all too many have failed. It is difficult to determine the measure of efficiency that has been attained. Descriptions of design and construction have often appeared in print, but these have seldom been followed with data as to the effectiveness of the fishway operation.

It would seem that fishways can be classified under two general heads, mechanical and flow types. In the former the fish are trapped or induced to enter a compartment at or near the downstream toe of the dam and, without effort on their part, are elevated to the waters above. It appears that past attempts in getting fish over dams by mechanical means have generally failed, probably due in part to disregard for the instincts of the fish. It may be, though, that there are possibilities of use that have not been developed as yet. The flow type of fishway has a contained and directed flow of water from above the dam to the

<sup>1</sup> Mr. Spencer, now Chief of the Bureau of Hydraulics, California Division of Fish and Game, prepared this paper while in the employ of the United States Bureau of Fisheries. Permission to publish the paper in CALIFORNIA FISH AND GAME was kindly given by the United States Commissioner of Fisheries.

downstream toe or its vicinity, and on a gradient low enough so that fish are able to ascend without appreciable difficulty to the waters above. This type seems to more nearly approach natural stream conditions and is effective within limits.

The subsequent matter contained herein is based on the writer's experience and observation of Pacific Coast conditions and in the main is with reference to the passing of trout and salmon. It is believed that these conditions are similar, or nearly so, in other sections of the country although some changes and adjustments may be necessary in fishway design.

While there are certain fundamentals that are to be carefully considered if an effective structure is to be had, it should be realized that each dam and its required fishway is a distinct problem by itself and must be so considered, and hence the design for a fishway may only be prepared after a complete study of all known data and an inspection of field conditions.

When the need of a fishway is being considered for a dam which is in place or contemplated, study should be made of the species of fish in the stream which will use it in their natural life cycle. Trout have a tendency to move to headwaters for spawning purposes and this upstream movement is necessary for anadromous fish, such as steelhead, shad and salmon. For certain other fish a dam is of no significance except as it may deprive them of desirable feeding areas. If there is sufficient movement of fish and enough spawning area above the dam to justify fishway construction, the other factors controlling design may be considered. Some dams and diversions may be of such design, or so operated, that they will in various ways so adversely affect fish life that fishway installation is unwarranted.

When it has been found that a fishway is required, detailed study must then be made of the species of fish that it is desired be passed over or around the dam. As the fishway is generally for all the different species in that stream, it is necessary that it be designed to permit the least energetic or able fish to reach the waters above the dam.

Some dams require more than one fishway, because the width of the stream, operating practices, or type of construction may tend to form separate channels or pockets, or all the different species may not be accommodated by a single installation.

Efficiency and economy will best be served if the fishway is made a part of the original dam design. This procedure necessitates cooperation between the representatives of the conservation agency and the designers of the dam. The fishway design will be based on results of studies of stream flow, heights of water in the reservoir, fluctuations and time intervals, maximum and minimum flows over the dam and when they occur, probable action of water below the dam, proposed operating practices when the dam is placed in operation, and maximum quantity of fish that will use the fishway at any one time. Consideration should also be given to possible changes in operating practices and their effect on fishway operation. The design should be sufficiently flexible to provide for such occurrences. Other factors which will be noted later should also be given careful thought. It is evident that if the conservation agency representative is to intelligently cooperate and



design a fishway, he should have engineering knowledge and water operations experience in addition to his other qualifications.

Data are generally available when designing a fishway for an existing dam. Records show stream flows, operating methods, water levels and other details. In addition, movements of fish at the base of the structure may sometimes be observed. The physical features, however, may be such that the proposed fishway installation is much more difficult and expensive when built afterward than if it had been included in the original construction.

The location of a fishway is important, especially its entrance. This should be at a point in or near the immediate vicinity of the line of travel of the fish, or where they usually congregate, and also must be close to the base of the dam and yet avoid too much of the overpour from the dam. At times the lower pools of the fishway may be submerged but some portion of the fishway should be readily accessible to the fish. If a power house is a part of the dam structure, or reasonably close, it may be that the fishway entrance can be near the power house tailrace. More than one entrance to a fishway may at times be desirable or necessary.

A location favored in some localities is somewhere on the dam and removed from the abutments, the thought being that an installation at such an inaccessible location will obviate tampering with the fishway and the removal of the fish. That is probably correct to an extent, but the disadvantage of this position is the difficulty of any adjustment during high waters and when fish are attempting to pass. Debris may lodge there making it inoperative, or partially so, for a time. It appears to the writer that the disadvantages of such a location are in excess of the benefits, though if fish naturally congregate in midstream difficulty might be encountered in diverting them to an entrance at or near the abutments.

The exit of the fishway into the waters above the dam should preferably be where the velocity of the water is low, and at a distance, if possible, from outlets or diversions. It should be protected from moving debris so that the waterflow through the fishway will not be interrupted and the fish not hindered in leaving the fishway.

With the entrance and the exit fixed, the designer now determines the type of fishway to connect these two points. The simplest design is to be preferred, one that will require the minimum of attention and maintenance, and yet be accessible to fish. The pool type of fishway appears to be reduced to the barest essentials and has been found satisfactory for trout and salmon. It is believed that this type may be satisfactory for less active fish, since carp and suckers have been observed proceeding upwards to a height of forty feet.

The pool type consists of the required number of boxes or pools, each higher than the preceding one by a determined distance (generally from 1 to  $2\frac{1}{2}$  feet), joined together in line with flowing water and direction of moving fish, and each having a stationary depth of water greater than the difference in elevation between the pools. Some pool types have the water flowing over the entire width of the end of each pool. This appears to be the general practice where there is an unlimited water supply, but when water is limited ports are an advantage.

The typical fishway has the ports on one side, thus giving a more uniform flow of water, obviating cross-currents in the pool and providing a greater area of quiet water for fish to rest in before proceeding to the next higher pool (see figure 32). The stationary water height is increased by the depth of the water flowing through the ports. The sides of the boxes are higher than the water level by three feet or more, depending on the size and species of fish using the device, to prevent fish from jumping out of the pools. The outside wall adjacent to the port is continued at the same elevation for a distance of about four feet on the next lower pool, forming an additional guard. It is desirable to have the water fall as close to the dividing wall of the pools as possible, and the thickness of the wall should be kept to a minimum. The pools should be ample in area so that no congestion will occur even during the heaviest movement of fish.

The difference in elevation between pools (jumps) is determined after considering the different fish to be passed, distance and obstacles overcome by the fish prior to arrival at the fishway, water conditions, available construction area, and general practicability of the proposed structure. For fishways of some length and height it is advisable to insert one or more larger pools which will serve for resting areas for the fish in their upward journey.

A regulated and even flow of water through a fishway is to be desired. Too great an amount will unnecessarily tire the fish. As the water level in the reservoir may fluctuate rapidly at times, it is necessary to regulate the

flow either manually or by mechanical means.

Where regulation will be required the maximum and minimum water levels of the reservoir are determined and this difference in elevation is distributed equally through the upper pools (counting down-stream from the exit), the determined jump from each pool not being exceeded for high water level in the reservoir. To accomplish this the floor of these upper pools is at the low water level regulation point, and in lieu

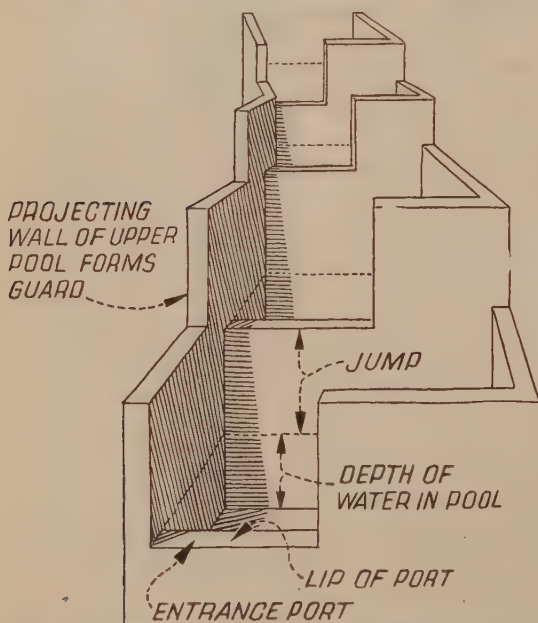


FIG. 32. Diagrammatic drawing of typical fishway, looking upstream. The principal features of the fishway are shown as they would appear when no water is flowing.

of the normal dividing wall between pools, check boards are used. These are adjusted for the proper heights or jumps, and also to permit of the desired flow of water for the different water levels in the reservoir. For mechanical regulation the construction in general is the same, but the ports or checks are operated mechanically.



FIG. 33. Fishway of concrete construction with a natural rock bank forming bottom and portion of one side. A float at the upper port regulates the amount of water flowing through the fishway.

Where there is no overpour from the dam the fish generally find the entrance of the fishway without difficulty. Intermittent flows over the dam may complicate fishway operations. Sometimes an auxiliary water supply carried directly to the entrance pool may be needed to attract the fish and induce them to enter the fishway. In streams where the fish move at well defined times, and where the supply of water is limited and valuable, it may not be necessary to pass water through the fishway except in these defined periods, although water flow in a stream at all times is of value.

The fishway may be constructed of lumber, masonry or concrete. It should be built to withstand severe high water conditions. The topography and natural formation may be utilized to good advantage, but the depth of water in the pools in the line of travel should not be lessened by any projecting rocks. A small opening on the floor and connecting the pools is desirable for draining and cleaning purposes, although it should be removed from the general line of travel so as not to form cross-currents or disturb the fish if they desire to rest on their upward journey.

Changes in the direction of the fishway should be kept to a minimum, but where they are necessary it will generally be of advantage to have larger and deeper pools. Comments that a fishway must have ample light may be correct, although it is known that salmon and trout have used fishways that were under the back face of a dam where light penetration was limited.



The writer is of the opinion that data are insufficient at this time to definitely say to what heights fishways may be constructed and be fully effective for certain species of fish. Some species are more energetic and better able to pass barriers than others. A fishway which has a total difference in elevation between entrance and exit of 70 feet has been entirely effective in passing all steelhead, the only noticeable species in that stream. The pools are 6 feet wide and 8 feet long. The depth of water is from 2 to  $2\frac{1}{2}$  feet, and the difference in elevation between pools (jumps) is  $2\frac{1}{2}$  feet. Two resting pools are provided. While the steelhead appear to have no difficulty in passing this dam, it is believed that larger pools, greater depth of water, and better placing of ports would be of advantage.

Designs of fishways to be used by salmon generally provide larger pools and greater depth of water than if only steelhead are being considered. This is necessary because salmon are larger, and probably not as energetic and capable of sustained effort in a fishway, and also because salmon should not be required to use up all of their energy in passing a dam but have sufficient remaining strength to complete their journey and life cycle. For salmon fishways it is believed that the maximum jumps should not exceed  $1\frac{3}{4}$  feet and should preferably be less, especially if the fishway is of any appreciable height. Topography and other physical features may necessitate exceeding this figure for a limited number of pools at times. It is desirable to have all jumps in a fishway equal in height. Salmon fishways are in successful operation to heights of 60 feet, but with proper design it is believed that this is not the limit.

The inclined plane system of fishways has baffles so set in a flume that the water takes a long sinuous course, thus reducing its velocity. For low dams these may be satisfactory, but it is believed that for dams of any height the pool type previously described will be more effective and economical and require less effort on the part of the fish.

The Cail type of fishway is, for practical purposes, the same as the pool type with the addition of an orifice on the floor level and in the cross wall between the pools. Fish which do not desire to jump over the cross wall or port may swim through the orifice. For fishways with relatively small pools the writer has found that these orifices or lower openings were disadvantageous, as cross-currents were produced which hinder fish movement. When the fishway was altered to the distinct pool type, salmon proceeded upward more readily.

## NOTES ON SARDINE GEAR CHANGES AT MONTEREY<sup>1</sup>

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During the 1936-1937 season, 93 different boats delivered sardines to processing plants in the Monterey region.<sup>2</sup> Only 75 of these boats can be considered as permanent; that is, they operated for 2½ months or longer. The other 18 boats can be considered as temporary; that is, they operated for less than 1½ months. Most of the temporary boats made only a few deliveries. Fifty-one of the 75 permanent boats were purse seine boats. Two of these were equipped with ring nets and carried no turntables. Ring nets are similar to purse seines in construction but differ mainly in that lighter weight webbing is used, and the ends of the net are tapered instead of square. The balance of the permanent boats, 24 in number, were launch and lighter combinations, all equipped with ring nets. Of the 18 temporary boats, 12 were purse seine boats and six were launch and lighter combinations.

The average hold capacity of the purse seine boats was 90 tons and the average lighter capacity of the launch and lighter combinations was 55 tons. The range of hold capacities for the entire purse seine fleet was 40 to 155 tons. The average hold capacity of the purse seine fleet during the 1936-1937 season was 14 tons greater than for the 1935-1936 season. The higher average hold capacity of the purse seine boats was due to a number of new locally owned boats of large capacity; eight of the boats that fished for the first time during the 1936-1937 season had hold capacities between 115 and 155 tons.

Thirty-four of the permanent fleet of purse seine boats were locally owned, 12 were chartered, mainly from Washington waters, by local crews, and five were outside boats with outside crews. All of the launch and lighter combinations were locally owned, survivors from previous years when the lampara net dominated the Monterey sardine fishery. Many of the former operators of these combinations now operate purse seine boats.

Purse seines averaged 190 fathoms long, or 10 fathoms more than for the previous season, 1935-1936. This was due to a greater number of larger boats. Ring nets of the launch and lighter combinations averaged about 138 fathoms in length, or within two fathoms of the previous season's average.

Many purse seine boats have discontinued the use of power on the turntable roller. It has been found that when power is applied to the roller, the net can not be pulled in as fast as the roller revolves, and

<sup>1</sup> Submitted for publication March 17, 1937.

<sup>2</sup> All but one of the sardine plants in the Monterey region are located at the town of Monterey. The one exception is located at Moss Landing, about 18 miles to the north of Monterey. This plant commenced operations in 1935.

this friction harms the net. The boom and rope-sling tackle that is used to haul aboard the bunched purse-rings, is also used to haul up slack net. This saves a great deal of time and labor when a water-haul is made. The washing and tanning of these heavy nets are simplified by the use of the boom and rope-sling.

Floats or "balloons" were universally adopted by the Monterey fleet of purse seine boats during the 1936-1937 season. The boats were equipped with five to ten of the floats, which were either entirely of rubber or with a canvas covering outside and a rubber bladder inside, filled with air. The all-rubber floats are preferred. These floats are between 16 and 24 inches in diameter. They are snapped along the cork line at intervals, while the net is being pursed, to prevent the cork line from sinking. An outside boat that made one delivery at Monterey was equipped with several metal floats. However, metal floats are not desirable because they are heavy and also bulky to stow away when not in use.



FIG. 34. The process of transferring a purse seine from boat directly into a tanning vat on Fishermen's Wharf, Monterey. The cork line is piled on the raised platform outside the vat. Note the use of the boom on boat for lifting a section of the heavy net. This arrangement is also used on the fishing grounds for lifting the bunched rings and slack net aboard the boat. Photograph by author, December, 1936.

Nets are preserved either by tanning them or tarring them. Some fishermen prefer one method, some the other. During the 1934-1935 and 1935-1936 seasons there were more tanned than tarred purse seines. The difference of opinion seems to be settled by a compromise—the fishermen now treat their nets both ways. The webbing of most of the purse seines used in the 1936-1937 season was tarred initially, and then tanned a few times during the season. This practice was started by a number of Monterey boats that went to Oregon to fish during the past two summers. Since there were no tanning facilities for the large nets at the Oregon ports, crews owning tanned nets tarred them before leaving Monterey.<sup>3</sup> When replacements were made with tanned webbing at Monterey, it was found by direct comparison that the tarred sections stood up better than the tanned sections. The main argument in favor of the tanned purse seine is that it is lighter and easier to handle, and has longer lasting qualities than a tarred net. However, the long length of life depends upon frequent washing and tanning (preferably twice a month) which is not always attended to, especially during inten-

<sup>3</sup> During the summer of 1936, a tanning barge for purse seines was constructed in Coos Bay.



sive fishing. When a net is tarred, the washing and tanning are not so imperative. The tanning can be done when convenient.

Tanning facilities for purse seine boats at Monterey have increased since 1934. Previous to 1934, any nets that were tanned had to be loaded on trucks and taken ashore. In 1934, a tanning scow was built, so that purse seines could be placed directly into a tanning vat from the boat. In 1936, another tanning unit was constructed, on Fishermen's Wharf, for the convenience of purse seine boats. Both of these tanning units are privately owned. In both cases, the tanning solution (chipped bark of the tanbark oak, plus water) is brought to a boil in a square metal tank, and then the hot solution is run off into a wooden vat that contains the net. There are two vats in the scow unit and three in the wharf unit. Each vat holds 4,500 to 5,000 gallons, and will accommodate one net. A net should remain in the tanning solution for at least five hours. Between 500 and 600 pounds of tanbark are required to tan a purse seine, and each batch of bark is used but once. The wharf unit used about 40 tons of tanbark during the 1936-1937 season. The charge for tanning was approximately \$38 for a purse seine and \$22 for a ring net.

## SETTING AND SURVIVAL OF SPAT OF THE OLYMPIA OYSTER, *OSTREA LURIDA*, ON UPPER AND LOWER HORIZONTAL SURFACES<sup>1</sup>

By Paul Bonnot

*Bureau of Marine Fisheries*

*California Division of Fish and Game*

Oyster larvae, in common with the young of many marine invertebrates, pass through a free swimming stage. At the completion of this phase of their existence, with the proper combination of environmental factors, the oyster larvae attach themselves to some stationary object and remain fixed thereafter.

It is at once apparent, when studying either natural or artificial oyster beds that the oyster larvae, under normal conditions set much more abundantly on the under side of horizontal surfaces. The degree to which this occurs has been studied by Hopkins (1935) who found, "that more than 6 times as many larvae attach to under horizontal surfaces as to the under surfaces of glass supported at an angle of 45°, and about 100 times as many as caught on vertical surfaces." Oyster larvae normally swim with the velum uppermost. The foot, the organ most instrumental in setting, is adjacent to the velum. Hopkins says further, "Presumably in nature, as the larvae are carried along with the current, the foot may cling to a surface with which it comes in contact. This, most frequently, would be an under surface, and the more nearly horizontal the surface the more likely the contact. If the above described explanation of the habit of attachment to under surfaces is correct it would be expected that in places where the water is highly turbulent the larvae would frequently be turned over and would become attached to upper surfaces also."

Prytherch (1928, page 494) says of the setting of the eastern oyster, *O. virginica*, "The heaviest setting was found near the bottom and on the lee side of the collectors, presumably because of the eddies created by them."

The present paper presents the results obtained with a new type of spat collector, used for the first time in Humboldt Bay, California, during the season of 1936, by the Humboldt California Oyster Growers. Because of the construction and manipulation of this collector a condition was created which encouraged the swimming oyster larvae to set on upper as well as lower surfaces.

The collectors were made up of strips of plywood one-eighth of an inch thick, each strip having an effective area of 2½ by 22 inches. The strips were fastened together in groups of five by narrow pieces of plywood across the ends. The strips were spaced one-half inch apart.

<sup>1</sup> Submitted for publication March 31, 1937.

Four of the units, of five strips each, were nailed to two 5-foot lengths of redwood  $\frac{3}{4}$  by 1 inch, with a 2-inch space between units. The completed section was dipped in a mixture of sand and cement and allowed to cure. The original idea was to obtain a maximum under surface by forming a battery of from 5 to 8 of these sections, one on top of the other. The flat surfaces were three-fourths of an inch apart (see figure 35).

The batteries were submerged in dikes, where even at low tide 6 or 8 inches of water is maintained. Comparatively long stakes were necessary to anchor the batteries to the bottom as they have a tendency to float and receive considerable pounding from wave action. The following results were observed: The surface facing the bottom, in most cases, took little or no spat, as almost without exception it touched the mud.



FIG. 35. Spat collector, not yet cemented, as used by Humboldt California Oyster Growers in Humboldt Bay. Photograph by Paul Bonnot, October 1, 1936.

The upper surface, on top of the battery, also took little. All other surfaces, however, took a heavy set of oyster larvae. Because of the fact that the individual batteries were spaced only 6 inches from each other the set was heaviest on the outside edges and became progressively lighter toward the center. One battery placed by itself at some distance from the others took an almost uniform set throughout. The set began about the 15th of May, reached a peak about the 15th of June and continued in progressively smaller peaks until the middle of August (Bonnot, 1937).

At the conclusion of the set fall, in August, it was estimated that the collectors had taken as many spat on the upper surfaces as on the lower. As the press of other activities did not allow time for an actual count, none was made, and when later it was deemed of interest to find



out what the percentage of spat on the two surfaces actually was, only a small section of a collector was available which could be accurately dated. On this piece, however, 14 square inches could be counted. As it was in the water for the approximate period of the setting time, June 1, 1936 to August 1, 1936, it gives a very good average of the spat fall (see table 1). On March 2, 1937, a unit of 5 strips was taken from the same dike from which the first section was obtained. It had been placed in the water on June 1, 1936. It was one of the end units of the second layer from the top of a battery. An area of 80 square inches was counted on this sample—one series of 20 square inches running across, and a second series along one of the outside strips. Each numbered square inch represents both an upper surface and its corresponding lower surface. In the case of the smaller section very few spat were dead. On the larger, very few dead shells were evident as they were probably over grown. The young oysters, in this case, were several times larger than those on the first piece. No dead shells were included in any of the counts.

TABLE 1

Spat Counts on Flat Collector, Put Out June 1, 1936, Taken Up August 1, 1936, One-inch Squares

| Number square        | Under surface | Upper surface |
|----------------------|---------------|---------------|
| 1                    | 27            | 105           |
| 2                    | 31            | 118           |
| 3                    | 33            | 93            |
| 4                    | 49            | 103           |
| 5                    | 38            | 89            |
| 6                    | 37            | 75            |
| 7                    | 40            | 107           |
| Totals-----          | 255           | 690           |
| Average per square-- | 36            | 98            |
| Average percentage-- | 27%           | 73%           |

The counts made on the small section of a collector, which was in the water for the duration of the set, and was therefore indicative of the intensity of the spat fall, showed an average of 98 spat per square inch on the upper surface, and 36 per square inch on the lower, or 73 per cent on the upper and 27 per cent on the lower. The average catch per square inch, taking into account both upper and lower surfaces, was therefore 67 spat. As the flat surfaces of the collectors are spaced only three-fourths of an inch apart and as the surfaces are comparatively rough because of their cement coating, considerable friction would be offered to a current, causing the water to roll and swirl. Under these conditions the swimming larvae would be carried along between the layers in all positions and it would seem logical that the slight pull of gravity would cause more of them to come to rest on the surface which was below them. Another very important factor is that this upper surface is almost entirely free of mud and silt because the narrow spaces tend to concentrate the flow of water and the swirling action washes the silt away, a condition not found in any other type of artificial collector.

The counts from the complete unit, which was left in position over the winter show a slightly different picture, although it is a logical

sequence based on growth (see table 2). A square inch of surface could not support more than 3 or 4 adult oysters, and as the average set per square inch was 67 it is obvious that unless the young oysters are removed several months after the set, the majority of them will be lost. At the end of eight months the numbers per square inch had already been drastically reduced, and although the upper surface started with a population three times that of the lower, the two surfaces were then approximately the same, with an average for both sides of 14.5 per

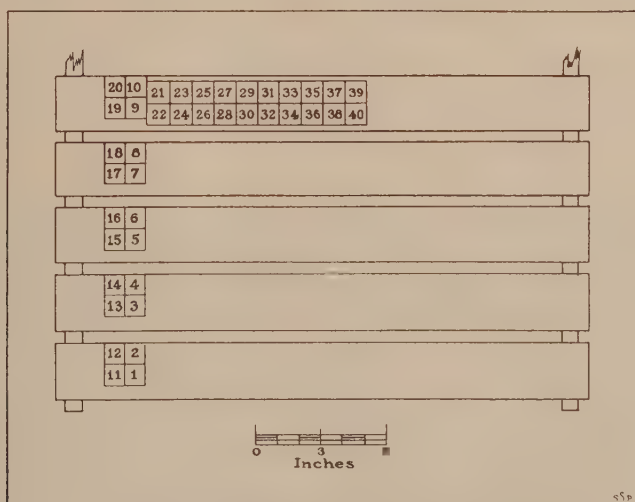


FIG. 36. Diagram of spat collecting unit, drawn to scale, showing position of numbered squares used in Table 2.

TABLE 2

Spat Counts on Flat Collector, Put Out June 1, 1936, Taken Up March 2, 1937, One-inch Squares

| Number square           | Under surface | Upper surface | Number square | Under surface | Upper surface |
|-------------------------|---------------|---------------|---------------|---------------|---------------|
| 1                       | 26            | 9             | 21            | 15            | 19            |
| 2                       | 12            | 17            | 22            | 17            | 11            |
| 3                       | 19            | 11            | 23            | 14            | 18            |
| 4                       | 17            | 16            | 24            | 16            | 14            |
| 5                       | 11            | 14            | 25            | 11            | 19            |
| 6                       | 16            | 5             | 26            | 20            | 12            |
| 7                       | 15            | 17            | 27            | 14            | 13            |
| 8                       | 15            | 15            | 28            | 14            | 8             |
| 9                       | 16            | 13            | 29            | 12            | 18            |
| 10                      | 11            | 9             | 30            | 16            | 22            |
| 11                      | 8             | 17            | 31            | 13            | 18            |
| 12                      | 15            | 11            | 32            | 10            | 12            |
| 13                      | 12            | 12            | 33            | 14            | 19            |
| 14                      | 19            | 19            | 34            | 15            | 12            |
| 15                      | 20            | 17            | 35            | 10            | 26            |
| 16                      | 21            | 6             | 36            | 19            | 15            |
| 17                      | 16            | 13            | 37            | 8             | 16            |
| 18                      | 10            | 6             | 38            | 12            | 10            |
| 19                      | 24            | 15            | 39            | 14            | 22            |
| 20                      | 15            | 6             | 40            | 14            | 13            |
| Totals.....             | 318           | 248           |               | 278           | 317           |
| Average per square..... | 16            | 12            |               | 14            | 16            |
| Average percentage..... | 57%           | 43%           |               | 47%           | 53%           |

square inch. If allowed to remain in situ it is probable that the oysters on the surfaces which face upward would all succumb, as the growing shells would gradually fill the spaces between the two layers of the collector, slowing the current and allowing an accumulation of mud and silt which would first smother the young oysters on the upper surface.

It would appear from the present demonstration that this system of spat catching is superior to any yet devised for taking oyster larvae, as the expectation per surface unit is more than doubled by the ability of the upper surfaces to catch spat.

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## THE CHUKAR PARTRIDGE OF ASIA<sup>1</sup>

By Gordon H. True, Jr.

Bureau of Game Conservation  
California Division of Fish and Game

The chukar, *Alectoris graeca chukar*, is one of twenty-two varieties of a single species of partridge that is found from northern China and Mongolia, through India, Persia and Arabia to Asia Minor and southern Europe. In Asia, this partridge ranges as far west as the Holy Land, and in Europe to the Alps and middle and southern Italy. The species, or rather group of closely related varieties to which the chukar



FIG. 37. Because of its protective coloration the chukar partridge can easily escape detection. There are four birds in the cactus garden shown above. Photograph by August Bade.

belongs, has a well-known relative in the person of the "Frenchman" or red-legged partridge of Europe, *Alectoris rufa rufa*, and another in the Barbary partridge, *Alectoris barbara barbara*, of the desert plains of North Africa.

The partridge which has been introduced into California is the Indian representative of this family of game birds and finds its optimum range along the southern slope of the Himalayas from Nepal to eastern Ladakh. The stock from which our chukars were obtained came to us from Calcutta, India.

<sup>1</sup> Submitted for publication June, 1937.

The chukar presents a striking appearance with his red beak and feet, black necklace around a white (sometimes buff) throat, and the handsome vertical bars of black and brown on his grey flanks. When seen in his natural surroundings, however, he blends so perfectly with the background that he may escape detection by the keenest observer through the simple expedient of just "sitting tight."

In choice of habitat, the chukar is one of the most versatile of birds. Hume, in "Indian Sporting Birds," states that, "in one place it faces a noonday temperature of 150 degrees F., in another braves a cold, about daybreak, of a little above zero: here it thrives where the annual rainfall exceeds 100 inches, and there flourishes where it is practically arid." Apparently the only climate that a chukar can not stand is the incessant damp of a rain forest. It is found at altitudes ranging from sea level to 16,000 feet. To quote again from Hume, the chukar is equally at home "on open grassy hillsides in the hot, low valleys; on stony screes covered with a light growth of barberry bushes and amongst snows at 12,000 feet." It is this ability of the chukar to survive under such a variety of conditions that has encouraged its introduction into California—a land of contrasts where this bird must certainly find a favorable environment.

In India, the chukar breeds in April or as late as September, depending on the altitude. A pair of birds will naturally take up housekeeping much later at an altitude of 16,000 feet than they will at a 1000-foot elevation. The nest is built in a hollow scratched in the ground which may or may not be lined with grass or leaves. The nest may be built in the open or in the protecting shelter of a stone or bit of herbage. Sowerby in "A Sportsman's Miscellany" remarks that the nest "is very hard to find, usually being carefully hidden amongst the boulders and scanty scrub at the base of cliffs or in narrow ravines and gorges." A chukar hen will lay on the average a clutch of fourteen eggs. The eggs are yellowish white and speckled to a varying degree with brown.

Sowerby states that "young hatched in June are fully fledged by the end of August. By September the chukars are fully grown and ready for shooting." During the fall months, the pairs with their rapidly maturing young gather into coveys of from thirty to several hundred birds. They remain in coveys throughout the winter, breaking up into pairs at the beginning of the next breeding season.

The food of the chukar consists of reeds, small fruits and berries, leaves, green shoots and some types of roots. They also take insects and insect larvae when they are available. Chukars are very fond of cultivated grains but seldom enter fields in which crops are standing. They prefer to glean in the open fields after the harvest.

Hume says that the chukar flies strongly, making downhill when flushed, but will lie after one good flight. All one needs is a good bird dog to have a perfect day's shooting. Observations made here in California, though very limited, corroborate the above statements. A covey of chukars was flushed in the middle of a brushy flat in San Bernardino County one fine day, about a month after they had been liberated from the Chino Game Farm. The birds, fourteen in all, sailed away to a point about two hundred yards distant and alighted on the ground. The observer hurried to the spot to find that the birds had disappeared

and ten minutes of concentrated looking and listening offered nothing in the way of a clue to their whereabouts. Still standing in the same spot, the investigator idly kicked at a small shrub a foot or so from his right toe and literally fell over backward when the shrub disgorged fourteen chukars, going at full speed in fourteen different directions. They lie close and come out fast.

Those who have been lucky enough to eat the chukar partridge properly cooked and served maintain that here is a table bird second to none. The young birds, distinguished by their black bills, are, of course, the best eating.

Chukars have been liberated in twenty-six counties in California since 1932, the year during which the first liberation was made. The heaviest plantings have been made in the southern part of the State due to the fact that there is in that region a vast area of arid land which is not now occupied by game species, and to which it is felt the chukar will adapt itself, thus putting formerly useless land to work for the sportsmen. Naturally, the chukar can not yet be hailed as a permanently established resident of our State. It can, however, be said of this new bird that it looks good.





FIG. 38. Upland game birds; left to right, Chukar partridge, mountain quail, valley quail and desert quail. The Chukar, introduced from Asia, is being propagated and distributed in barren and mountainous regions of California where other game birds are scarce. The mountain quail, as its name implies, inhabits brush and forest lands in the mountains of California. The valley quail, the official bird of the State, is found in the valleys and foothills. The desert quail is a denizen of the arid southeastern part of the State. Photograph by Lee Passmore, reproduced through his courtesy.

## THE CHUKAR PARTRIDGE IN CALIFORNIA <sup>1</sup>

By August Bade

*Superintendent of State Game Farms  
California Division of Fish and Game*

Before the advent of civilization, California had an abundance of game birds, but their numbers have decreased alarmingly. The principal native upland birds included sage hen, blue grouse, valley quail and mountain quail. Of these, only the "king of the chaparral," the California valley quail, remains in goodly numbers.

Several years ago it became apparent that something had to be done to restore hunting. As a beginning, the ring necked pheasant was introduced into agricultural sections. While this stocking of pheasants was going on, a careful survey of the State was made to find out just what we had in the way of natural habitat for other upland game birds. Within California is found every conceivable climatic condition and habitat range—miles of coastal area, vast irrigated valley stretches and high mountain territory, as well as thousands of square miles of desert. The most particular or fussy bird can find the counterpart of its natural home some place in our State. In fact, the survey showed that we had ranges suitable for several kinds of pheasants, partridges, quail and turkeys. At the same time we began casting about for suitable birds.

In selecting a bird for introduction, the uppermost questions are, will it fit into our program as a game bird, and can it be reproduced artificially? Both of these points are important. Furthermore, in order to make a successful transplanting it is quite necessary to know in more or less detail the natural habitat of the bird under consideration. If this habitat can be duplicated there will be very little trouble in establishing any imported species. The ring necked pheasant and the Hungarian partridge are outstanding examples to bear out this statement. In many places in the United States these two fine game birds have come to be looked upon as the chief source of upland game bird shooting.

In building up our California game bird propagating system we have recognized certain species of birds and discarded others. It is our opinion that if a bird is to stand up and make progress it must have certain characteristics. The birds must be able to reproduce in considerable numbers even in the face of adverse circumstances. In short, they must be smart. With good roads, good cars and firearms, plus an eager public, it is no time or place for dumb-bells.

The chukar partridge seems to qualify as a desirable bird. It is smart and has the added advantage of its camouflaged color scheme. Those black stripes along its sides, as well as its red legs and bill, cause it to blend into almost any kind of cover. Imagine these birds in a habitat where granite rocks predominate. They become invisible in

<sup>1</sup> Submitted for publication March, 1937.

such surroundings and are only seen as they take wing with a whirl and a burst of speed equaled by few game birds.

We have said that the game bird of today must be smart and capable of being reproduced artificially. In my estimation, and this appraisal is based on several years' experience with the birds, the chukar partridge is the answer to the sportsmen's prayer and the realized hope of the game breeder.

During one season at the Yountville farm we had two hens that laid 106 and 112 eggs respectively. A year later another female, possibly an offspring of one of these high egg producers, began laying on the 10th of March and kept on laying till she had produced 136 eggs. She had not only laid a large number of eggs, but better still, over 95 per cent of them were fertile.



FIG. 39. Two-thirds grown chukar partridges in rearing pens at the Yountville State Game Farm. Photograph by August Bade.

As examples of what can be done in breeding chukars domestically, we can cite two examples. A retired business man of San Francisco took up game bird raising as a hobby. From 13 pairs of chukars this man reared over 400 birds to maturity. He raised these birds purely for table purposes. About the first of November he presented 30 of his club associates with six birds each. One of the recipients, a man who had always contended there was no table bird like the California valley quail, wrote me a letter in which he stated, "The chukar partridge is a better table bird than the quail."

Another man who had become interested in the chukar partridge, and wanted to reproduce them, obtained twelve pair as his foundation stock. The twelve females laid 980 eggs for the season. Although it was his first season as a game breeder he hatched out over 500 chicks and reared about 350 to maturity.



This egg producing quality and adaptability to domestic conditions are characteristics of the pheasant, quail and partridge, and are factors that make them especially valuable for restocking purposes. In contrast, many of our native species are very deficient in egg production—the first requisite of any game bird that is to play an important part in restocking programs of the future. They are not only low in egg production, but are very easily discouraged if their nests are molested during the reproducing season. On the other hand, the pheasant, partridge and quail are imbued with the idea of perpetuating their kind and they will usually do it if it takes them all summer.

The question naturally arises, will they behave before a dog? The answer is yes, and this information comes from men who have hunted them in their native habitat. In Asia, the chukar is a favorite game bird.

About two years ago a gentleman came to the Yountville Game Farm and inquired about chukar partridges, saying that he had read in a newspaper that we had some and he would like to see them. As he gazed at several dozen of them he remarked, "That is the same bird." He was a retired naval man and lived only a short distance from the farm. During his enlistment he was stationed at Shanghai for seven years. On several occasions during that period he was sent out on scouting expeditions. On one of these trips he and his party went up the Yangtze River and into the back country of Mongolia. At times, he said, they lived on the meat of the chukar for weeks, and here is the most significant statement of all—"Don't let any one tell you that the chukar partridge isn't the best eating bird in the world."

Our experience with the chukar dates from 1928. At that time our department purchased five pair. At least they were supposed to be five pair. We secured these birds late in the season and gave them little attention on account of a heavy pheasant and quail program. By the next season we had time to study and observe them. Five more "pair" were secured direct from Calcutta, India. These five pair turned out to be nine males and one female. But with what we had reared the first year we now had enough to start a foundation stock. At the close of 1936 we had reared and released 4600, and we have over 600 for breeding stock in 1937.

The proof of the pudding is in the eating, so the saying goes. What proof have we that the chukar partridge is making good and reproducing in a natural state? In California we have found the nests, made pictures of nesting females, checked the young birds in several stages of development and otherwise watched their progress. These birds have been released in about 80 different sections of the State under many different altitude and climatic conditions. In no instance have the birds disappointed. Two or three examples, selected at random, indicate that the chukar is here to stay.

In Siskiyou County, fifteen pair of birds were released in March. No other chukars have ever been released in that locality. The following December over 90 partridges were counted in that area. On one ranch in Kern County the riders reported finding five nests in the month of May. In this particular area about 15 pair of birds had been released.

So far as California is concerned we think the chukar is a valuable game bird as it takes well to the more arid and desert-like areas. In fact it is living up to its reputation as "the bird that lives on nothing." As a matter of record we have had them reproduce on the Mojave Desert. In Kings Canyon, Los Angeles County, a nest of ten eggs was found. The eggs hatched on the 13th day of August, 1935. If there is any hotter, dryer place on the face of the earth, especially in the month of August, we do not know where it is. Any bird that can breed there has a place in California.

From our experience with the bird in California I would say they do best in a dry climate where the altitude ranges from 1000 to 4000 feet. We are using them to stock the more or less barren and wasteland sections of the State where at the present time there are no game birds of any kind.

When considered from every angle it seems to be the best bird for our State that it has been our good fortune to handle—a good producer under domestic conditions, a fine game bird, and the bird supreme as a table delicacy. What more could one wish? May this fine game bird continue to meet with favor and do its part in rebuilding the upland game bird supply of our country.

## CALIFORNIA'S JUNIOR GAME PATROL<sup>1</sup>

By M. F. Joy, Jr.

*Warden, Superintendent Junior Game Patrol  
California Division of Fish and Game*

The Junior Game Patrol was first organized in 1936 by the Division of Fish and Game because of the need for educating society in the principles of conservation, so that the Division's work in the preservation of California's resources for the benefit of the public may not be in vain. The number of violations of the fish and game laws in California since 1926 has increased greatly, and it was apparent that a large proportion of the violators were young men between the ages of 21 and 30. The purpose of conservation is to assure the constant use of the resources and to leave a sufficient breeding stock, and the fish and game laws are therefore enacted by the people of the State to aid in the management and wise utilization of the resources. Hence, the Bureau of Patrol of the Division of Fish and Game is vested with the duties of enforcement of these laws. The Bureau's aim is to make the public realize the significance of the inestimable damage that can be done through carelessness and of their responsibility in preserving Nature's gifts for future generations, and it is not the Bureau's sole purpose to apprehend violators as so many are prone to believe. This is in keeping with the modern trend to prevent rather than punish. For example, since 1926, there have been 23,345 persons arrested and convicted for fish and game violations in this State, but many of these offenses could have been prevented. Fines for such violations amounted to nearly half a million dollars and the violators served some 70,000 days in jail, an aggregate of 191 years. Although it may be too late to educate the older people, we can do a great deal of good by teaching our youth the principles of conservation so they will not become violators.

A plan, originated and furthered by Mr. A. T. Jergins, Fish and Game Commissioner of California, was therefore initiated to educate our younger generation along these conservation lines, teaching them to appreciate and protect the wildlife, the perpetuation of which is in the hands of the public. Such was the origin of the Junior Game Patrol, which is making even more rapid strides than the Division of Fish and Game had anticipated. The sportsmen's organizations have aided materially in furthering this work by taking an active interest.

The Junior Patrol, under the direct supervision of the Division, is made up of troops, the members of which are boys of 10 to 21 years of age. Their membership is solicited throughout the schools, and the troops are locally sponsored by sportsmen's clubs, civic organizations or interested individuals. The sponsoring agency furnishes the required adult supervision, namely, troop leaders—one for each platoon consisting of 19 boys—and also special instructors whenever necessary. If the

<sup>1</sup> Submitted for publication June, 1937.



patrol leaders are adept in some particular phase of the program, such as natural history, specimen mounting, drilling, sport fishing, etc., their knowledge will be of benefit to the troop. However, in any case the officers of the Division of Fish and Game are prepared to instruct in specialized conservation fields in addition to directing the general activ-



FIG. 40. A Ranger of the Junior Game Patrol. The uniform is modeled on that of the Canadian Northwest Mounted Police.

ities. The sponsor of the troop provides a meeting place, which is usually a civic hall, school or other convenient place.

In organizing a troop, a group of boys is called together by the Division of Fish and Game and the purpose of the Junior Game Patrol is explained to them. The boys are given literature on fish and game

laws and on natural history subjects, and are provided with applications for membership. Weekly meetings are held thereafter. After four weeks of instructions on fish and game laws and the reasons for them, a preliminary examination is given. The successful boys take the oath of office and are given badges and credentials signed by the three California Fish and Game Commissioners and the Division's Executive Officer. Thus, they become Rangers of the Junior Game Patrol. Then they are ready to commence with the course of instructions, outlined below, which is made as interesting as possible. Field trips are an important feature, as it is only through actual contact



FIG. 41. The badge of the Junior Game Patrol.

with nature that the desired results can be secured. The course consists of the following activities:

- Instructions in fish and game laws and the reasons for them.
- Identification of birds, fish and other animals; mounting of specimens.
- Drill work.
- Fishing—fly and bait casting.
- Making of flies and leaders, rewinding rods.
- Hunting in field; dog training.
- Hiking, camping, forest fire prevention.
- Rifle and pistol shooting.
- Trapping; predatory animal control.
- Athletics.
- Red Cross life saving.

Game management on the farm; restoration of cover for upland game; soil erosion.

Game bird raising.

The organization of the patrol is as follows:

| Squad        |    | 1 Company               |    |
|--------------|----|-------------------------|----|
| 1 Corporal   | 1  | 4 Platoons              | 64 |
| 3 Rangers    | 3  | 8 Sergeants             | 8  |
|              | 4  | 4 Lieutenants           | 4  |
|              |    | 2 Captains              | 2  |
| 1 Platoon    |    |                         | 78 |
| 4 Squads     | 16 | 1 Troop                 |    |
| 2 Sergeants  | 2  | Any number of companies |    |
| 1 Lieutenant | 1  | 1 Major                 |    |
|              | 19 |                         |    |
| 2 Platoons   |    |                         |    |
| 1 Captain    |    |                         |    |



FIG. 42. The shoulder insignia of the Junior Game Patrol.

The Division of Fish and Game has designed uniforms (see Fig. 40) for these boys, and the cost is approximately \$7.75 each. The sponsoring agency, if it so desires, may uniform the boys but the Division of Fish and Game recommends that the funds for their purchase be raised by the rangers themselves through social functions or other means. There never should be any financial obligation on the part of the individual member or his parents. In this way, the uniforms will be the property of the troop.

At the present time (June, 1937), there are approximately 250 members who have received their commissions. The average age of the boys is 15 years. Troops have been organized in San Francisco, Oak-

land, Tracy, Stockton, Napa and in Marin County, and sponsored by the following clubs:

Foothill Sportsmen's Club, Oakland  
 San Francisco Rod and Gun Club, San Francisco  
 Ingle-side Sportsmen's Club, San Francisco  
 Daly City Sportsmen's Club, San Francisco  
 Tracy Wildlife Association, Tracy  
 Napa Rod and Gun Club, Napa  
 Marin Rod and Gun Club, San Rafael

FRANK F. MERRIAM, GOVERNOR



State of California

## Division of Fish and Game

[Dated] FEBRUARY 2, 1937

By the Authority of the Fish and Game Commission

ALAN C. WILSON

of FOOTHILL JUNIOR SPORTSMEN CLUB

County of ALAMEDA, State of California,

is hereby constituted and appointed a

RANGER

of the

## Junior Game Patrol

Fish and Game Commission

*E. C. Moore*  
 President

*Greenwood*  
*A. J. Higgins*  
*Robert Davis*  
 Executive Officer

I will endeavor to be a good sportsman and work for the conservation of fish and game at all times. My aim will be to build my body and character clean, fine and strong, in keeping with the great outdoors.

*Alan C. Wilson*

FIG. 43. A Ranger's commission in the Junior Game Patrol, signed by the three Fish and Game Commissioners and the Executive Officer of the Division of Fish and Game.



The rangers are not vested with any law enforcement authority and it is not the intention of the Division to grant it. Above all, they are not to work in the guise of "stool-pigeons." They are taught conservation practices, to appreciate and protect wildlife, to be aware of the beauties of nature, to be sportsmanlike, and in general to become better citizens for having become rangers. These boys can carry the knowledge thus gained to their homes and associates and so spread the conservation movement. They will understand that violating fish and game laws and the laws of the forest is not smart or clever, but a dishonorable crime against nature. We know this work is worthwhile but we need the public's cooperation and assistance in order to make this "conservation through education" undertaking a Statewide organization.

## EDITORIALS AND NOTES

VOLUME 23

JULY, 1937

No. 3

### BUREAU OF MARINE FISHERIES

The Fish and Game Commission, at its meeting on June 19, 1937, ordered the name of the Bureau of Commercial Fisheries changed to Bureau of Marine Fisheries, as it was believed the new title more nearly fits the functions of the Bureau. This change, in name only, became effective July 1, 1937.



Fig. 44. One of the two new fisheries patrol cruisers placed in service by the Division of Fish and Game in June, 1937. Photograph by E. L. Macaulay, San Francisco, California.

### TWO NEW PATROL BOATS PLACED IN SERVICE

The marine fisheries patrol in southern California waters has recently been increased by the assignment of two new cruisers, the *Marlin* to San Diego, and the *Bonito* to Santa Barbara. These boats, commissioned on June 12, 1937, are 45 feet long, with 10-foot beam, and are powered by twin screw gas engines capable of developing a speed in excess of 25 knots when necessary. They have sleeping accommodations for two men and sufficient fuel tank capacity to permit them to make distant trips from their home stations.

The *Marlin* and the *Bonito* cost approximately \$12,000 each, with complete equipment. This is considerably more than the cost of the *Yellowtail*, a boat of similar type and construction which was placed in service September 21, 1936, and is stationed at Newport.—E. L. Macaulay, Chief, Bureau of Patrol, Division of Fish and Game, June, 1937.

### B. D. MARX GREENE

B. D. Marx Greene, former Executive Officer and Attorney of the Fish and Game Commission, died at San Francisco on February 20, 1937. His death came as a great shock to his many friends in California.

Mr. Greene was appointed to the position of Attorney on August 21, 1924. He served in that capacity until January 18, 1926, at which time the offices of Executive Officer and Attorney were combined. He was appointed to both offices and held them with distinction until his resignation on December 1, 1927. During his term of office the Division of Fish and Game was reorganized, and he instituted many beneficial changes which are still in effect. He will long be remembered for his progressive term of office.

At its meeting on April 10, 1937, the Fish and Game Commission unanimously adopted the following resolution:

WHEREAS, In the death of B. D. Marx Greene, former Executive Officer and Attorney of this Commission, the State has lost a man who rendered outstanding service in behalf of fish and game conservation; and

WHEREAS, The Fish and Game Commission wish to give recognition of the valuable services rendered by the deceased while in the employ of the Commission; be it

*Resolved*, That an expression of sympathy be incorporated in the minutes of this meeting and that a copy of such resolution be mailed to the bereaved family.

—Richard S. Croker,  
*Editor, "California Fish and Game"*

### THE MOLLUSKS OF LAKE TAHOE

Lake Tahoe, one of the largest lakes in the western United States, lies near the crest of the Sierra Nevada on the California-Nevada boundary at an elevation of 6225 feet. It catches the drainage from a considerable area close by but has no large inlets. It drains to the north, then east by Truckee River, which in turn empties into the closed basin of Pyramid Lake, Nevada.

For many years it has been known that there are a few species of fresh-water mollusks in Truckee River,<sup>1</sup> but so far as we have discovered Lake Tahoe is without a record. This seems strange in view of the size of the lake, and the purity of its waters and the number of conchologists who have visited it. Many have made fruitless search of its shores and shallow waters. Several attempts by us indicated that this was not the proper method for collecting if the lake were not barren. This seemed inconceivable because other conditions were such that mollusks could hardly be absent.

Reasoning from analogy with similar large lakes it seemed possible that in this case also these animals would be found in relatively deep water. Therefore a dredge was taken to the lake in October, 1933, and several hauls were made in depths up to 50 fathoms off Chambers Lodge on the west side. In every case beyond 20 fathoms, shells were found among the water plants which came up. This procedure was

<sup>1</sup>Carleton, Henry P. Shells of Truckee River and Vicinity. *Proc. Calif. Acad. Sci.*, Vol. 4, 1869, p. 57.

followed on August 13, 1936, with equally good or better results in 30 fathoms off Homewood Resort.

The discovery of shells and the names of the few species found seem worthy of record. These are: *Pisidium* sp., *Parapholyx effusa* (Lea), *Carinifex newberryi* (Lea), *Valvata humeralis californica* Pilsbry, and *Lymnaea* sp.

Undoubtedly additional species will be found when more thorough dredging is undertaken. Tracks and furrows in the white sand off Chambers Lodge resembled those made by *Anodonta* but no specimens or fragments were obtained.

The above, however, were not the first shells actually collected in the lake. During the interval from December, 1926 to March, 1927, James Moffitt collected six lesser scaup ducks there which had fed on mollusks. The stomach contents of these birds were 100 per cent animal matter; a very considerable part of this consisted of fragments and entire shells of *Carinifex newberryi* (Lea). The identification was made by E. R. Kalmbach of the U. S. Biological Survey.—*G. D. Hanna and A. G. Smith, California Academy of Sciences, June, 1937.*

### A SILVER SALMON AT LOS CORONADOS ISLANDS

On June 20, 1937, a party boat was fishing near Los Coronados Islands which are out from San Diego and just south of the international boundary line between the United States and Mexico when one of the party trolling an aluminum jig hooked a silver salmon, *Oncorhynchus kisutch*, estimated to weigh between 9 and 10 pounds. The fish was examined by N. B. Scofield, H. B. Nidever and the writer on June 21 and there was no doubt as to the identification. This, so far as we know, is the southernmost record of the occurrence of this fish along the Pacific Coast.—*W. L. Scofield, California State Fisheries Laboratory, June 23, 1937.*

### MONTEREY SPANISH MACKEREL TAKEN AT LONG BEACH

A specimen of the very rare Monterey Spanish mackerel, *Scomberomorus concolor*, was taken at Long Beach, California, on May 20, 1937. It was caught on hook and line, with a live sardine for bait, inside the harbor. The present specimen, a two-foot female containing ripening eggs, is the second fish of this species to be reported from southern California.

As its name suggests, the Monterey Spanish mackerel is found most often at Monterey, California. Or rather, it used to be found at Monterey—for it disappeared from sight nearly 50 years ago, and only two specimens have been reported there since. From 1870 to 1890 it was fairly common in Monterey Bay, and commanded a high price on the market. About 1890, the fish vanished for some inexplicable reason. Since then only a few have been recorded anywhere. Boulenger reported its occurrence (as *Cybium concolor*) in the Gulf of Panama, but he did not state how many were seen (Boll. Mus. Zool. Anat. Torino, XIV, No. 346, 1899, 3). No one has reported one at Panama



since. One was observed at the San Pedro fish markets in 1927. Two more were caught at Monterey in 1931 (J. B. Phillips, Calif. Fish and Game, Vol. 18, No. 1, p. 99).

The occasional recurrence of this fish indicates that somewhere in the ocean, beyond the ken of man, there is a stock that is maintaining the species.—*Richard S. Croker, California State Fisheries Laboratory, June 17, 1937.*

### **SNAKE EEL, *OPHICHTHUS TRISERIALIS*, TAKEN OFF SAN PEDRO**

The waters off southern California constitute a transition area between colder waters of the temperate zones and warmer waters of the tropics. Many species of fish are common to this transition zone either as permanent residents or as seasonal visitors entering from the north or south, tarrying some months and returning to their former habitats. In addition to residents and annual visitors we occasionally find stragglers in our waters which have wandered well beyond their normal range.

Such a straggler was brought into the San Pedro fish markets on the morning of June 4, 1937. This fish, identified at the California State Fisheries Laboratory as a snake eel, *Ophichthus triserialis* (Kaup), was caught by a hand-line boat close to Los Angeles Harbor, probably off Point Firmin. The fish, still alive when brought in, caused much wonderment in the markets because of its snake-like appearance. There are many kinds of snake eels, all inhabitants of tropic seas. *O. triserialis* is commonly found from Lower California to the Galapagos Islands, but this capture off San Pedro apparently constitutes the northernmost record of its distribution. Our specimen was a female, 36 inches in length, with maturing eggs. That she would have spawned successfully in these waters seems doubtful.—*Frances N. Clark, California State Fisheries Laboratory, June 7, 1937.*

### **FURTHER NOTES ON THE JUMBO SQUID, *DOSIDICUS GIGAS***

Considerable surprise was evoked among fishermen and scientists when large numbers of the previously rare jumbo squid, *Dosidicus gigas*, appeared off the California coast during the summer of 1934. In waters where one had been a rarity, thousands appeared almost overnight (Frances N. Clark and J. B. Phillips, Calif. Fish and Game, Vol. 22, No. 2, pp. 143-144, 1936). Since 1934, the jumbo squid has ceased to be a novelty and indeed has become a pest.

This animal is an active, predaceous marine mollusk. It is one of the largest of our squids. Those that first appeared in southern California during 1934 and 1935 were 2 to 2½ feet in length and weighed about 5 pounds. Those caught in 1937 were much larger, averaging over 20 pounds; some weighed more than 30 pounds. At first they appeared only in the summer, but later they occurred throughout the year.

Considerable numbers of these squid were seen during the summers of 1934 and 1935. After a few trial landings it was found that there was no sale for them, hence no fishery was developed.

In 1936 they seemed to be even more abundant all the way from Monterey Bay to San Diego. It was in this year that they were first recognized as a nuisance by the fishermen. Albacore trollers were first bothered with them striking the jigs. Usually the squid pulled loose, but they invariably left some of their tender anatomy on the hooks to foul them. Those that were caught squirted slippery, insoluble ink on the decks much to the disgust of the fishermen. Rockfish set liners complained bitterly that the squid not only stole all the bait from their lines, but also damaged the fish that had been caught on the hooks.

The plague of jumbo squid has been worse in 1937. Set line, net and troll commercial fishermen are still bothered by them, and in addition sport fishermen have been harrassed all spring. No sooner does a pleasure boat start to fish than a horde of squid appears on the scene to crowd the game fish away and seize all the baits. When one is hooked, it proceeds to shower boat and fishermen with ink and water, and then delights in biting its captor with its parrot-like beak. Several fishermen have been seriously bitten this year. Although squid fishing is hilarious sport for a few minutes, it becomes too much of a good thing day after day. During 1937, the squid have been caught in large numbers at least as far south as the Coronado Islands.

To the best of our knowledge, no one has yet devised a way to make the jumbo squid palatable when prepared for the table. Consequently there has been no effort to capitalize on the present supply by developing a fishery for it. However, several fishermen have requested that the State pay a bounty on the squid in order to encourage their destruction.—*Richard S. Croker, California State Fisheries Laboratory, June 18, 1937.*

## TWO NEW SARDINE BULLETINS

Two bulletins dealing with the California sardine fishery have recently been issued in the series of Fish Bulletins prepared by staff members of the California State Fisheries Laboratory. Both of these bulletins were written by Frances N. Clark in nontechnical language, although the first one concerns the rather complicated subject of fluctuating sizes of fish occurring in the commercial catch. This is Fish Bulletin 47, "Interseasonal and Intraseasonal Changes in Size of the California Sardine, *Sardinops caerulea*." The second bulletin, number 48, "Fishing Localities for the California Sardine, *Sardinops caerulea*, 1928-1936," is particularly clear and brief in treatment.

Essential in the study of the California sardine is an understanding of the two important fluctuations in size of fish that are characteristic of this fishery. The greater of the two size changes is a regular one occurring year after year within each season. It is a change from small fish in summer to medium sized fish in the fall and to large fish in the winter. The other change in size of fish is from one season to another. It occurs irregularly and is of lesser magnitude than the cycle of change within each season. Fish Bulletin 47 is a comprehensive account of the occurrence, characteristics and significance of these two types of size fluctuations occurring in the sardine catch at the various fishing ports of the State.

The bulletin summarizes the results of studies of fish size, inaugurated in 1919 and carried on continuously for the last sixteen years at

Monterey and San Pedro, with additional data for recent years at San Diego and San Francisco.

The change in fish sizes within each season is brought about, not by growth, but by size selective migrations into and out of each of the fishing localities of the State. The medium sized fish supplying the fall fishery represent three or four age classes of young fish, sexually immature or having spawned but once or twice. By contrast, the winter fishery draws from many more age classes, but chiefly from large sexually mature adults that have spawned several times. These two classes, fall and winter fish, behave so differently that they must be considered separately, almost as though we had two distinct sardine fisheries along our coast. Size studies of these two classes of fish in the different regions of the State have been the basis for the theories of migrations as worked out by the staff of the California State Fisheries Laboratory and now being checked by tagging experiments.

The irregular difference in fish sizes from one season to another is due to the success or partial failure of spawning, which affects the relative abundance of fish in each age class making up the population. Following an unusually successful spawning season the resulting superabundant age group has been recognized and traced in the catch of the following years for a period of eight or ten seasons. In recent years the dominance of the occasional superabundant age group has seemed to pass more quickly and the fact that such a group can now be traced but three or four years in the commercial catch is considered as one of the several danger signs indicating that our sardine population is suffering from excessive utilization. This bulletin, offered for publication in September, 1935, predicted that the heavy strain, especially upon the young fish of our fall fishery, if not abated, will result in serious depletion.

Fish Bulletin 48 is a concise general discussion of sardine fishing localities, comparing the areas throughout the entire State and considering their relationship to depth of ocean waters and distances from shore and from points of delivery.

Detailed observations of the sardine fishery and sampling of the catch have been conducted without interruption since 1919. The first ten years, from 1919 to 1929, covered the period of development of the canning industry and rapid expansion of the ocean areas. Detailed accounts of change in fishing localities during this period have been published previously so that Bulletin 48 deals chiefly with the last eight fishing seasons, 1928-29 to 1935-36. This later period has been a time of comparative stability so far as fishing areas are concerned, except for the development of new grounds off San Francisco with the establishment of canning plants in the Bay Region.

The discussion of catch locality in relation to ocean depths concludes that in the Monterey fishery practically no catches were made except over the continental shelf inside the 100-fathom contour line. In southern California the fishing appears to concentrate over the steep slope of the continental shelf, between the 100- and 500-fathom contour intervals with very few catches made in waters deeper than 500 fathoms.

Graphic charts summarize the data relating locality of catch to distance from the shore line so that the reader may see at a glance the

percentage of catches falling inside each one-mile distance interval from shore. Practically all catches are less than 18 miles from shore and the proportion occurring inside the 3-mile State boundary line (not always 3 miles from shore) is 75 per cent for the Monterey region and 38 per cent for the San Pedro fishery.

An outstanding feature of this bulletin is the presentation of three maps of the State's coastline to illustrate features of the sardine fishery. The first map shows ocean depths in 100-fathom intervals, upon which have been superimposed dots, each of which represents the point at which a sardine catch was made. The reader may determine for himself the relationship between ocean depth and locality of catch and see the concentration of catches occurring on the continental shelf or along the steep seaward face of the shelf.

The second map is of special interest as it pictures the serially numbered blocks into which the ocean waters off this State have been divided, and each block carries a symbol representing the number of tons of fish caught from the block. This map is thus a graphic yield table for each portion of the ocean from Point Arena to the southern boundary of the State for the 1935-1936 sardine fishing season. It is a record of the crop harvested from each field and is a step toward the goal of true conservation management under which each area is administered upon the basis of sustained annual yield, thus affording the fullest possible continuous utilization of the area.

The third map also represents catch localities as dots but in this case they are related to the 3-mile State boundary line. With the absence of depth contours the concentration of catches near certain headlands is more clearly illustrated.—*W. L. Scofield, California State Fisheries Laboratory, Terminal Island, California, June, 1937.*

## GRAPHIC HISTORY OF THE COMMERCIAL FISH CATCH

Answering the call of the fisheries administrators, we present the Division's Fish Bulletin number 49, as a handy reference book for those concerned with the commercial fish catch. There has been gathered into one "catch bulletin" a set of graphic charts and a short history of each of the commercial species, whether it ranks high in importance or is merely listed occasionally in the tables of landings. For comparative purposes the graphs will at a glance answer many pertinent questions. We call particular attention to the list of references which will supply a valuable key for those who wish to pursue the subject of any one species in greater detail than the author felt necessary to give.

Fish Bulletin number 49 is the fifth in a series of catch bulletins originating at the California State Fisheries Laboratory, the fruits of the statistical system (previous ones were Fish Bulletins 15, 20, 30 and 44). Its title, "The Commercial Fish Catch of California for the Year 1935," would infer that it deals only with statistics for 1935. The detailed tables are for that year alone, but the text covers the statistics from 1916 to date. The data used in its compilation were gathered and compiled through the combined efforts of the staff of the Bureau of Commercial Fisheries. The articles, with the exception of one, are contributions of the staff members of this bureau.

The authors were permitted considerable license and their enthusiasm has lifted this bulletin out of the plane of a mere textbook. Their



efforts to add a dash of color and express the individuality of the species with which they dealt has made interesting reading material out of a volume of facts.

To round out its usefulness, the bulletin contains special articles on value of the catch, canned products, oil and meal production, fish livers, the commercial fishing fleet and the fishermen.—*Geraldine Conner, California State Fisheries Laboratory, May, 1937.*

### MARINE FISHES OF SOUTHERN CALIFORNIA

A notable contribution to the study of California fishes was published by the University of California Press late in 1936. It is a 209-page book, entitled "Marine Fishes of Southern California," by Percy Spencer Barnhart, ichthyologist at Scripps Institution of Oceanography, La Jolla. This book contains brief descriptions of all native and introduced species of marine fishes known to occur between Pt. Conception and San Diego. Capable black and white drawings of 290 species of fish, made by the author, illustrate the book. These illustrations, which are more than mere outline sketches, comprise one of the finest groups of fish drawings we have seen. The book contains several keys to families and genera, and has a glossary, bibliography, index of common names and index of scientific names. No serious fisherman or student of fishes can afford to be without a copy.—*Richard S. Croker, Editor, "California Fish and Game," June, 1937.*

### MARINE GAME FISHES OF THE PACIFIC COAST

Early in 1937 a noteworthy handbook of fishes made its appearance, as a contribution of the Santa Barbara Museum of Natural History. Lionel A. Walford, who wrote it, and the University of California Press, who published it, can well be proud of "Marine Game Fishes of the Pacific Coast from Alaska to the Equator." Dr. Walford, who is now with the United States Bureau of Fisheries and was for a number of years on the research staff of the California Division of Fish and Game, has studied Pacific Coast fishes at first hand and speaks with authority.

The book, containing 205 pages and 69 plates, concerns itself with game fishes only, although it has a key to all the families of fishes occurring on the Pacific Coast. All the game fishes are discussed in more or less detail, some at considerable length, with scientific descriptions, life history notes and angling instructions. The style of writing is pleasing and should be acceptable to scientists as well as to sportsmen for whom the book is primarily intended.

The text is accompanied by a remarkable collection of illustrations. There are 60 black and white photographs and wash drawings of fish as well as many outline sketches, not to mention a number of illustrations of fishing gear and baits. However, the color illustrations of fish, 57 in number, are so outstanding that they overshadow the black and white. The color paintings and wash drawings are by Link Malmquist. The natural color photography is by Ralph Emerson, who also made many of the black and white photographs. A number of photographs were loaned by the California State Fisheries Laboratory.—*Richard S. Croker, Editor, "California Fish and Game," June, 1937.*

## REPORTS

### STATEMENT OF REVENUE

For the Period July 1, 1936, to March 31, 1937, of the Eighty-eighth Fiscal Year

Revenue for Fish and Game Preservation Fund:

Current Year:

License Sales:

|                                                                    |              |
|--------------------------------------------------------------------|--------------|
| Angling licenses, 1936                                             | \$423,690 50 |
| Angling licenses, 1937                                             | 17,675 00    |
| Commercial hunting club licenses, 1936-1937                        | 750 00       |
| Commercial hunting club operators' licenses, 1936-1937             | 145 00       |
| Deer tags, 1936                                                    | 126,852 00   |
| Fish breeders' licenses, 1936                                      | 30 00        |
| Fish breeders' licenses, 1937                                      | 305 00       |
| Fish importers' licenses, 1936                                     | 5 00         |
| Fish importers' licenses, 1937                                     | 70 00        |
| Fish packers' and wholesale shellfish dealers' licenses, 1936-1937 | 1,100 00     |
| Fishing party vessel permit, 1937                                  | 41 00        |
| Fishing party vessel permit, 1936                                  | 59 00        |
| Game breeders' licenses, 1936                                      | 120 00       |
| Game breeders' licenses, 1937                                      | 817 50       |
| Hunting licenses, 1934-1935                                        | 661 16       |
| Hunting licenses, 1935-1936                                        | 19,851 00    |
| Hunting licenses, 1936-1937                                        | 238,085 50   |
| Kelp licenses, 1936                                                | 10 00        |
| Market fishermen's licenses, 1936-1937                             | 41,760 00    |
| Market fishermen's licenses, 1937-1938                             | 620 00       |
| Trapping licenses, 1936-1937                                       | 1,867 00     |
| Total license sales                                                | \$874,514 66 |

Other income:

|                           |                |
|---------------------------|----------------|
| Court fines               | \$52,457 29    |
| Fish packers' tax         | 252,413 85     |
| Fish tag sales            | 1,986 04       |
| Game tag sales            | 188 94         |
| Importers' contributions  | 230 00         |
| Interest on bank balances | 5,201 51       |
| Kelp tax                  | 158 35         |
| Lease of kelp beds        | 1,309 20       |
| Miscellaneous sales       | 4,495 97       |
| Publication sales         | 222 88         |
| Salmon tax, Chap. 1015-35 | 16,888 71      |
| Total other income        | \$335,552 74   |
| Grand total               | \$1,210,067 40 |

## STATEMENT OF EXPENDITURES

For the Period July 1, 1936, to March 31, 1937, of the Eighty-eighth Fiscal Year—Continued

| Function                                        | Salaries<br>and<br>wages | Materials<br>and<br>supplies | Service<br>and<br>expense | Property<br>and<br>equipment | Total        |
|-------------------------------------------------|--------------------------|------------------------------|---------------------------|------------------------------|--------------|
| <b>Operating Expenditures—88th Fiscal Year:</b> |                          |                              |                           |                              |              |
| Administration:                                 |                          |                              |                           |                              |              |
| Executive                                       | \$3,749 94               |                              |                           |                              | \$3,749 94   |
| General office                                  | 4,290 00                 | \$1,120 02                   | \$601 30                  | \$97 47                      | 6,108 79     |
| Printing general                                |                          | 2,254 80                     |                           |                              | 2,254 80     |
| Printing, fish and game magazine                |                          | 922 07                       |                           |                              | 922 07       |
| Automobiles                                     |                          | 257 28                       | 188 14                    |                              | 445 42       |
| Traveling                                       |                          |                              | 1,713 18                  |                              | 1,713 18     |
| Postage                                         |                          |                              | 3,443 62                  |                              | 3,443 62     |
| Telephone and telegraph                         |                          |                              | 2,766 76                  |                              | 2,766 76     |
| Freight, cartage and express                    |                          |                              | 601 66                    |                              | 601 66       |
| Rent                                            |                          |                              | 8,047 36                  |                              | 8,047 36     |
| Accident and death claims                       |                          |                              | 2,827 20                  |                              | 2,827 20     |
| Department administration pro rata              | 8,629 99                 |                              | 190 65                    |                              | 8,820 64     |
| Librarian                                       | 1,200 00                 | 152 50                       | 44 46                     | 114 57                       | 1,511 53     |
| Legal                                           |                          |                              | 3,252 08                  |                              | 3,252 08     |
| Premiums on bonds                               |                          |                              | 35 00                     |                              | 35 00        |
| Publicity                                       |                          |                              | 1,090 60                  |                              | 1,090 60     |
| Pro rata General Fund expense, Chap. 923-33     |                          |                              | 1,561 28                  |                              | 1,561 28     |
| Sales tax on sales                              |                          |                              | —1 05                     |                              | —1 05        |
| Total Administration                            | \$17,869 93              | \$4,706 67                   | \$26,362 24               | \$212 04                     | \$49,150 88  |
| Patrol and Law Enforcement:                     |                          |                              |                           |                              |              |
| Chief and assistants                            | \$11,098 06              |                              |                           |                              | \$11,098 06  |
| General office                                  | 3,711 51                 | \$51 58                      | \$49 22                   | \$68 17                      | 3,880 48     |
| Automobiles                                     |                          | 25,653 53                    | 9,700 59                  | 20,153 82                    | 55,507 94    |
| Traveling                                       |                          |                              | 38,204 79                 |                              | 38,204 79    |
| Postage                                         |                          |                              | 594 05                    |                              | 594 05       |
| Telephone and telegraph                         |                          |                              | 1,528 31                  |                              | 1,528 31     |
| Freight, cartage and express                    |                          |                              | 1 93                      |                              | 1 93         |
| Rent                                            |                          |                              | 616 48                    |                              | 616 48       |
| Captains and wardens                            | 155,434 05               | 568 15                       | 837 15                    | 115 41                       | 156,954 76   |
| Launches                                        | 6,219 10                 | 7,231 72                     | 5,049 83                  | 460 91                       | 18,961 56    |
| Premiums on bonds                               |                          |                              | 20 98                     |                              | 20 98        |
| Temporary help                                  | 490 81                   |                              |                           |                              | 490 81       |
| Assistant fish and game wardens, seasonal       | 20,269 56                |                              |                           |                              | 20,269 56    |
| Heat, light, water and power                    |                          |                              | 5 47                      |                              | 5 47         |
| Total Patrol and Law Enforcement                | \$197,223 09             | \$33,504 98                  | \$56,608 80               | \$20,798 31                  | \$308,135 18 |
| Commercial fisheries:                           |                          |                              |                           |                              |              |
| Chief and assistant                             | \$7,830 00               |                              |                           |                              | \$7,830 00   |
| General office                                  | 6,434 11                 | \$43 77                      | \$19 49                   | \$174 00                     | 6,671 37     |
| Automobiles                                     |                          | 490 39                       | 143 78                    | 623 15                       | 1,257 32     |
| Travel                                          |                          |                              | 5,390 42                  |                              | 5,390 42     |
| Telephone and telegraph                         |                          |                              | 578 23                    |                              | 578 23       |
| Freight, cartage and express                    |                          |                              | 127 85                    |                              | 127 85       |
| Rent                                            |                          |                              | 121 51                    |                              | 121 51       |
| Heat, light, water and power                    |                          |                              | 444 46                    |                              | 444 46       |
| Research (oyster)                               | 1,710 00                 | 33 11                        |                           |                              | 1,743 11     |
| Laboratory                                      | 22,250 42                | 1,812 70                     | 1,374 01                  | 1,032 72                     | 26,469 85    |
| Fish tags                                       |                          | 177 98                       |                           |                              | 177 98       |
| Cooperative research                            |                          | 29 50                        | 750 00                    |                              | 779 50       |
| Statistics                                      |                          | 397 21                       | 1,585 54                  | 168 62                       | 2,151 37     |
| Temporary help                                  | 687 09                   |                              |                           |                              | 687 09       |
| Terminal island grounds                         | 750 00                   | 23 73                        | 4 68                      | 7 67                         | 786 08       |
| Fish cannery auditing                           |                          |                              | 2,135 00                  |                              | 2,135 00     |
| Total Commercial Fisheries                      | \$39,661 62              | \$3,008 39                   | \$12,674 97               | \$2,006 16                   | \$57,351 14  |
| Fish Conservation:                              |                          |                              |                           |                              |              |
| Chief and assistants                            | \$5,275 81               | \$4 53                       |                           |                              | \$5,280 34   |
| General office                                  | 3,698 72                 | 11 33                        | \$11 55                   | \$3 03                       | 3,724 63     |
| Automobiles                                     |                          | 6,757 84                     | 2,627 66                  | 9 19                         | 9,394 69     |
| Traveling                                       |                          |                              | 6,745 42                  |                              | 6,745 42     |
| Postage                                         |                          |                              | 134 34                    |                              | 134 34       |
| Telephone and telegraph                         |                          |                              | 794 42                    |                              | 794 42       |
| Freight, cartage and express                    |                          |                              | 381 66                    |                              | 381 66       |
| Rent                                            |                          |                              | 1,256 49                  |                              | 1,256 49     |
| Heat, light, water and power                    |                          |                              | 1,530 24                  |                              | 1,530 24     |
| Research                                        |                          | 5 06                         | 227 67                    | 10 17                        | 242 90       |
| Fish planting                                   |                          | 599 69                       | 1,720 50                  | 14 30                        | 2,343 49     |
| Hatcheries                                      | 82,047 08                | 37,090 90                    | 736 92                    | 724 97                       | 120,599 87   |
| Fish cars                                       | 1,350 00                 | 1 44                         | 962 64                    |                              | 2,314 08     |
| Blue printing                                   |                          |                              | 2 58                      |                              | 2 58         |
| Cooperative research                            | 1,753 23                 | 154 15                       | 169 05                    | 21 33                        | 2,097 76     |
| Statistical                                     | 1,123 71                 | 77                           | 628 37                    |                              | 1,952 85     |

## STATEMENT OF EXPENDITURES

For the Period July 1, 1936, to March 31, 1937, of the Eighty-eighth Fiscal Year—Continued

| Function                                                                                     | Salaries<br>and<br>wages | Materials<br>and<br>supplies | Service<br>and<br>expense | Property<br>and<br>equipment | Total        |
|----------------------------------------------------------------------------------------------|--------------------------|------------------------------|---------------------------|------------------------------|--------------|
| Temporary help.....                                                                          | \$700 19                 |                              |                           |                              | \$700 19     |
| Special field.....                                                                           | 10,230 00                | \$23 13                      | \$5 21                    |                              | 10,258 34    |
| Fish rescue.....                                                                             | 1,440 00                 | 41                           | 25 50                     |                              | 1,465 91     |
| Assistant fish and game wardens, seasonal.....                                               | 19,615 29                |                              |                           |                              | 19,615 29    |
| Total Fish Conservation.....                                                                 | \$127,234 03             | \$44,649 25                  | \$18,169 22               | \$782 99                     | \$190,835 49 |
| Hydraulics:                                                                                  |                          |                              |                           |                              |              |
| Chief and assistant.....                                                                     | \$5,887 96               |                              |                           |                              | \$5,887 96   |
| General office.....                                                                          | 1,440 00                 | \$49 38                      | \$5 86                    | \$22 36                      | 1,517 60     |
| Automobiles.....                                                                             |                          | 290 54                       | 70 70                     | 10 97                        | 372 21       |
| Traveling.....                                                                               |                          |                              | 1,803 29                  |                              | 1,803 29     |
| Telephone and telegraph.....                                                                 |                          |                              | 1 20                      |                              | 1 20         |
| Blue printing.....                                                                           |                          |                              | 26 76                     |                              | 26 76        |
| Temporary help.....                                                                          | 84 64                    |                              |                           |                              | 84 64        |
| Total Hydraulics.....                                                                        | \$7,412 60               | \$339 92                     | \$1,907 81                | \$33 33                      | \$9,693 66   |
| Game Conservation:                                                                           |                          |                              |                           |                              |              |
| Chief and assistants.....                                                                    | \$11,478 30              |                              |                           |                              | \$11,478 30  |
| General office.....                                                                          | 3,060 00                 | \$77 14                      | \$26 25                   | \$28 21                      | 3,191 60     |
| Automobiles.....                                                                             |                          | 1,666 65                     | 580 65                    | 1,889 78                     | 4,137 08     |
| Traveling.....                                                                               |                          |                              | 2,690 14                  |                              | 2,690 14     |
| Telephone and telegraph.....                                                                 |                          |                              | 332 78                    |                              | 332 78       |
| Freight, cartage and express.....                                                            |                          |                              | 92 14                     |                              | 92 14        |
| Heat, light, water and power.....                                                            |                          |                              | 2,160 80                  |                              | 2,160 80     |
| Maintenance of game farms.....                                                               | 8,654 97                 | 12,044 97                    | 224 67                    | 1,973 81                     | 22,898 42    |
| Statistics.....                                                                              | 473 87                   | 1 22                         | 824 75                    |                              | 1,299 84     |
| Temporary help.....                                                                          | 5,150 68                 |                              |                           |                              | 5,150 68     |
| Maintenance of game refuges.....                                                             | 3,758 00                 | 948 29                       | 125 50                    | 11 64                        | 4,843 43     |
| Total Game Conservation.....                                                                 | \$32,575 82              | \$14,738 27                  | \$7,057 68                | \$3,903 44                   | \$58,275 21  |
| Licenses:                                                                                    |                          |                              |                           |                              |              |
| General office.....                                                                          | \$11,055 00              | \$808 53                     | \$147 22                  | \$2 16                       | \$12,012 91  |
| Printing licenses and applications.....                                                      |                          | 2,437 77                     |                           |                              | 2,437 77     |
| Traveling.....                                                                               |                          |                              | 257 18                    |                              | 257 18       |
| Postage.....                                                                                 |                          |                              | 884 08                    |                              | 884 08       |
| Freight, cartage and express.....                                                            |                          |                              | 43 39                     |                              | 43 39        |
| Premiums on bonds.....                                                                       |                          |                              | 1,051 17                  |                              | 1,051 17     |
| Identification license buttons.....                                                          |                          | 9,617 86                     |                           |                              | 9,617 86     |
| License commissions.....                                                                     |                          |                              | 43,106 19                 |                              | 43,106 19    |
| Total licenses.....                                                                          | \$11,055 00              | \$12,864 16                  | \$45,489 23               | \$2 16                       | \$69,410 55  |
| Special Item:                                                                                |                          |                              |                           |                              |              |
| State Fair and other exhibits (Payable from Support, Chap. 341-35 or E. O. for Support)..... | \$40 00                  | \$117 37                     | \$1,200 00                |                              | \$1,357 37   |
| Total, 88th Fiscal Year:                                                                     |                          |                              |                           |                              |              |
| Expense paid from Support appropriations.....                                                | \$433,072 09             | \$113,929 01                 | \$169,469 95              | \$27,738 43                  | \$744,209 48 |
| Prior year, 87th fiscal year, for Support.....                                               |                          |                              |                           |                              | 13,051 49    |
| Total, 87th and 88th fiscal years, for Support.....                                          |                          |                              |                           |                              | \$757,260 97 |
| Special Items:                                                                               |                          |                              |                           |                              |              |
| Predatory Animal Control:                                                                    |                          |                              |                           |                              |              |
| 88th fiscal year:                                                                            |                          |                              |                           |                              |              |
| Chief and assistants.....                                                                    | \$2,725 00               |                              |                           |                              | \$2,725 00   |
| General office.....                                                                          | 668 38                   |                              |                           | \$25 00                      | 693 38       |
| Automobiles.....                                                                             |                          | \$2,299 69                   | \$647 00                  | 13 12                        | 2,959 81     |
| Traveling.....                                                                               |                          |                              | 2,039 99                  |                              | 2,039 99     |
| Predatory animal control.....                                                                | 13,030 50                | 1,113 56                     | 4,502 56                  |                              | 18,646 62    |
| Predatory animal hunters and trappers, seasonal.....                                         | 4,500 00                 |                              |                           |                              | 4,500 00     |
| Total, 88th fiscal year.....                                                                 | \$20,923 88              | \$3,413 25                   | \$7,189 55                | \$38 12                      | \$31,564 80  |
| Prior year, 87th fiscal year, special item—Predatory animal control.....                     |                          |                              |                           |                              | \$68 25      |
| Total Predatory Animal Control, 87th and 88th fiscal years.....                              |                          |                              |                           |                              | \$31,633 05  |
| Total operating expenditures, 87th and 88th fiscal years.....                                |                          |                              |                           |                              | \$788,894 02 |



## STATEMENT OF EXPENDITURES

For the Period July 1, 1936, to March 31, 1937, of the Eighty-eighth Fiscal Year—Continued

| Function                                                                                                                          | Salaries<br>and<br>wages | Materials<br>and<br>supplies | Service<br>and<br>expense | Property<br>and<br>equipment | Total        |
|-----------------------------------------------------------------------------------------------------------------------------------|--------------------------|------------------------------|---------------------------|------------------------------|--------------|
| Expenditures for additions and betterments:                                                                                       |                          |                              |                           |                              |              |
| Permanent improvements:                                                                                                           |                          |                              |                           |                              |              |
| Purchase of game refuges and public shooting grounds and construction, improvements and equipment, Chap. 341-35.....              | \$13,234 93              | \$18,898 59                  | \$7,666 75                | \$16,934 04                  | \$56,734 31  |
| Prior year, 87th fiscal year:                                                                                                     |                          |                              |                           |                              |              |
| Construction, improvements and equipment and purchase of game refuges and public shooting grounds, Chap. 341-35, all objects..... |                          |                              |                           |                              | \$1,908 47   |
| Total permanent improvements, 87th and 88th fiscal years.....                                                                     |                          |                              |                           |                              | \$58,642 78  |
| Contributions to Employees' Retirement System, 88th fiscal year.....                                                              |                          |                              |                           |                              | 12,193 68    |
| Total current biennium.....                                                                                                       |                          |                              |                           |                              | \$859,730 48 |
| Prior biennium appropriations:                                                                                                    |                          |                              |                           |                              |              |
| Operating expenditures—                                                                                                           |                          |                              |                           |                              |              |
| 85th fiscal year:                                                                                                                 |                          |                              |                           |                              |              |
| Special Item:                                                                                                                     |                          |                              |                           |                              |              |
| Claim of Chief Accounting Officer, Department of Finance, Chap. 991-33.....                                                       |                          |                              |                           | —71 00                       | —71 00       |
| Total 85th fiscal year.....                                                                                                       |                          |                              |                           |                              | —71 00       |
| 88th fiscal year:                                                                                                                 |                          |                              |                           |                              |              |
| Special Item:                                                                                                                     |                          |                              |                           |                              |              |
| Construction Russian River Jetties, Chap. 984-33.....                                                                             |                          |                              | \$167 56                  |                              |              |
| California Code Commission, Chap. 645-33.....                                                                                     |                          |                              | 1 50                      |                              |              |
| Total operating expenditures, 88th fiscal year.....                                                                               |                          |                              |                           |                              | \$169 00     |
| Total prior biennium appropriations.....                                                                                          |                          |                              |                           |                              | 98 00        |
| Grand total.....                                                                                                                  |                          |                              |                           |                              | \$859,828 48 |

## FISH CASES

January, February, March, 1937

| Offense                                                                                                                                        | Number<br>arrests | Fines<br>imposed | Jail<br>sentences<br>(days) |
|------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|------------------|-----------------------------|
| Abalones; closed season; undersize; possession sliced in closed season.....                                                                    | 54                | \$909 00         | 297½                        |
| Angling; no license.....                                                                                                                       | 21                | 212 00           | 2                           |
| Bass, sea; undersize.....                                                                                                                      | 1                 |                  |                             |
| Bass, striped; overlimit; possession for sale.....                                                                                             | 5                 | 250 00           |                             |
| Clams; offering for transportation; overlimit; undersize; selling overlimit; out of shell.....                                                 | 46                | 1,787 50         | 115                         |
| Commercial fishing; no license.....                                                                                                            | 12                | 185 00           |                             |
| Crabs; closed season; possession female; undersize.....                                                                                        | 12                | 170 00           | 25                          |
| Fishing; closed area, season; false statement in procuring license; failure to produce license on demand; use, possession prohibited gear..... | 32                | 810 00           | 12½                         |
| Lobsters; oversize; undersize.....                                                                                                             | 5                 | 30 00            | 10                          |
| Night fishing.....                                                                                                                             | 2                 | 50 00            |                             |
| Operating smokehouse; no packer's license.....                                                                                                 | 1                 |                  |                             |
| Pollution.....                                                                                                                                 | 13                | 825 00           |                             |
| Salmon; gaffing; transporting.....                                                                                                             | 2                 | 60 00            |                             |
| Trout; closed district, season; overlimit.....                                                                                                 | 8                 | 55 00            | 10                          |
| Tuna; selling underweight.....                                                                                                                 | 7                 | 300 00           |                             |
| Totals.....                                                                                                                                    | 221               | \$5,643 50       | 472                         |

## SEIZURES OF FISH AND GAME

January, February, March, 1937

| Game:             |       | Fish:                  |        |
|-------------------|-------|------------------------|--------|
| Deer              | 13    | Abalone                | 585    |
| Deer hides        | 25    | Abalone, pounds        | 2,556  |
| Deer meat, pounds | 1,001 | Bass, sea, barrels     | 60     |
| Doves             | 7     | Bass, striped          | 28     |
| Ducks             | 1,577 | Bass, striped, pounds  | 200    |
| Eagle             | 1     | Blue cod, pounds       | 4      |
| Goose             | 1     | Clams                  | 1,461  |
| Mudhens           | 22    | Cockles, pounds        | 225    |
| Non-game birds    | 132   | Crabs                  | 44     |
| Pheasants         | 19    | Lobsters               | 298    |
| Quail             | 206   | Lobsters, pounds       | 110    |
| Rabbits           | 11    | Lobster pots           | 3      |
| Squirrels         | 2     | Perch                  | 43     |
| Swan              | 2     | Salmon, pounds         | 150    |
|                   |       | Set line               | 1      |
|                   |       | Skipjack tuna, pounds  | 873    |
|                   |       | Trout                  | 503    |
|                   |       | Trout, pounds          | 150    |
|                   |       | Yellowfin tuna, pounds | 29,393 |

## GAME CASES

January, February, March, 1937

| Offense                                                                                                                                                             | Number arrests | Fines imposed | Jail sentences (days) |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|---------------|-----------------------|
| Bird nets; possession                                                                                                                                               | 1              | \$25 00       |                       |
| Concealed weapon carried                                                                                                                                            | 1              | 25 00         |                       |
| Deer; killing, possession doe, spotted fawn, spike buck; closed season, district; dogs running deer; no tags; failure to fill out tag                               | 62             | 3,121 00      | 1,703                 |
| Disturbing traps                                                                                                                                                    | 2              | 20 00         |                       |
| Doves; closed season                                                                                                                                                | 2              | 50 00         |                       |
| Ducks; closed season; overlimit                                                                                                                                     | 74             | 4,377 50      | 1,115                 |
| Eagle; possession                                                                                                                                                   | 1              | 100 00        |                       |
| Firearms in refuge                                                                                                                                                  | 7              | 35 00         |                       |
| Geese; closed season                                                                                                                                                | 2              | 100 00        |                       |
| Grouse; possession                                                                                                                                                  | 1              | 10 00         |                       |
| Hunting; closed area, season; no license; in refuge; false statement in procuring license; failure to produce license on demand; alien purchasing citizen's license | 78             | 1,296 50      | 40½                   |
| Illegal shooting                                                                                                                                                    | 27             | 655 00        | 10                    |
| Mudhens; closed season                                                                                                                                              | 5              | 70 00         |                       |
| Night hunting                                                                                                                                                       | 2              | 100 00        |                       |
| Non-game birds; killing, possession, pursuit of                                                                                                                     | 31             | 675 00        | 10                    |
| Pheasants; closed season; overlimit                                                                                                                                 | 10             | 150 00        | 10                    |
| Pigeons; closed season                                                                                                                                              | 1              |               |                       |
| Protected birds; possession                                                                                                                                         | 1              | 5 00          |                       |
| Quail; overlimit; closed season; failure to tag domesticated                                                                                                        | 4              | 63 56         | 50                    |
| Rabbits; closed season                                                                                                                                              | 3              | 150 00        |                       |
| Rail; killing                                                                                                                                                       | 2              |               |                       |
| Swan; possession, killing                                                                                                                                           | 6              | 200 00        |                       |
| Trapping; no license                                                                                                                                                | 1              | 2 00          |                       |
| Tree squirrel; possession                                                                                                                                           | 4              | 100 00        |                       |
| Trespass                                                                                                                                                            | 13             | 132 50        |                       |
| Totals                                                                                                                                                              | 371            | \$11,463 06   | 2,938½                |

## FRESH FISH IMPORTATIONS\* FROM FOREIGN COUNTRIES FOR JANUARY, FEBRUARY AND MARCH, 1937

Compiled by the Division of Fish and Game, Bureau of Marine Fisheries

| Species                  | Landed in<br>Region 70,<br>Los Angeles | Landed in<br>Region 80,<br>San Diego | Total pounds |
|--------------------------|----------------------------------------|--------------------------------------|--------------|
| Barracuda.....           | 125,306                                | 108,928                              | 234,234      |
| Cabrilla.....            | 21,366                                 | 66,608                               | 87,974       |
| Corbina, Mexican.....    | 48,450                                 | -----                                | 48,450       |
| Grouper.....             | 1,930                                  | 36,055                               | 37,985       |
| Halibut, California..... | 11,407                                 | 129,514                              | 140,921      |
| Mackerel, Spanish.....   | 4,311                                  | 2,889                                | 7,200        |
| Perch.....               | -----                                  | 287                                  | 287          |
| Rock Bass.....           | 9,192                                  | 1,536                                | 10,728       |
| Rockfish.....            | -----                                  | 72,183                               | 72,183       |
| Sea-bass, Black.....     | 58,972                                 | 37,318                               | 96,290       |
| Sea-bass, Totuaya.....   | 242,711                                | 19,640                               | 262,351      |
| Sea-bass, White.....     | 303                                    | 6,266                                | 6,569        |
| Shark.....               | 831                                    | 223                                  | 1,054        |
| Sheepshead.....          | 745                                    | 1,759                                | 2,504        |
| Smelt.....               | -----                                  | 793                                  | 793          |
| Tuna, Albacore.....      | 136,377                                | -----                                | 136,377      |
| Tuna, Bonito.....        | 10,233                                 | 65,247                               | 75,480       |
| Tuna, Oriental.....      | 82,010                                 | -----                                | 82,010       |
| Tuna, Skipjack.....      | 1,782,499                              | 641,696                              | 2,424,195    |
| Tuna, Yellowfin.....     | 2,460,244                              | 12,781,122                           | 15,241,366   |
| Whitefish.....           | 1,736                                  | 3,702                                | 5,438        |
| Yellowtail.....          | 34,884                                 | 414,130                              | 449,014      |
| Crustacean:              |                                        |                                      |              |
| Lobster, Spiny.....      | 1,530                                  | 629,314                              | 630,844      |
| Prawn.....               | 1,125                                  | -----                                | 1,125        |
| Shrimp.....              | 9,569                                  | -----                                | 9,569        |
| Total pounds.....        | 5,045,731                              | 15,019,210                           | 20,064,941   |

\* These importations are included in tables of landings. They include fish caught by California boats in foreign waters as well as frozen fish imported for canning in California plants.

## FRESH FISH IMPORTATIONS BY POINT OF ORIGIN\* FOR JANUARY, FEBRUARY AND MARCH, 1937

Compiled by the Division of Fish and Game, Bureau of Marine Fisheries

| Species             | Gulf of California | West coast Lower California | International waters south U.S. boundary (definite origin unknown) | Mexican Mainland, Central and South America | Japan     | Total pounds |
|---------------------|--------------------|-----------------------------|--------------------------------------------------------------------|---------------------------------------------|-----------|--------------|
| Barracuda           |                    | 234,234                     |                                                                    |                                             |           | 234,234      |
| Cabrilla            | 9,740              | 78,234                      |                                                                    |                                             |           | 87,974       |
| Corbina, Mexican    | 48,450             |                             |                                                                    |                                             |           | 48,450       |
| Grouper             | 1,185              | 36,800                      |                                                                    |                                             |           | 37,985       |
| Halibut, California |                    | 140,921                     |                                                                    |                                             |           | 140,921      |
| Mackerel, Spanish   |                    | 7,200                       |                                                                    |                                             |           | 7,200        |
| Perch               |                    | 287                         |                                                                    |                                             |           | 287          |
| Rock Bass           |                    | 10,728                      |                                                                    |                                             |           | 10,728       |
| Rockfish            |                    | 72,183                      |                                                                    |                                             |           | 72,183       |
| Sea-bass, Black     | 1,234              | 95,056                      |                                                                    |                                             |           | 96,290       |
| Sea-bass, Totuava   | 262,351            |                             |                                                                    |                                             |           | 262,351      |
| Sea-bass, White     |                    | 6,569                       |                                                                    |                                             |           | 6,569        |
| Shark               |                    | 1,054                       |                                                                    |                                             |           | 1,054        |
| Sheepshead          |                    | 2,504                       |                                                                    |                                             |           | 2,504        |
| Smelt               |                    | 793                         |                                                                    |                                             |           | 793          |
| Tuna, Albacore      |                    |                             |                                                                    |                                             | 136,377   | 136,377      |
| Tuna, Bonito        |                    | 75,395                      | 85                                                                 |                                             |           | 75,480       |
| Tuna, Oriental      |                    |                             |                                                                    |                                             | 82,010    | 82,010       |
| Tuna, Skipjack      |                    | 107,760                     | 842,128                                                            | 276,283                                     | 1,198,024 | 2,424,195    |
| Tuna, Yellowfin     |                    | 147,786                     | 9,620,619                                                          | 5,472,961                                   |           | 15,241,366   |
| Whitefish           |                    | 5,438                       |                                                                    |                                             |           | 5,438        |
| Yellowtail          |                    | 408,059                     | 40,955                                                             |                                             |           | 449,014      |
| Crustacean:         |                    |                             |                                                                    |                                             |           |              |
| Lobster, Spiny      |                    | 630,844                     |                                                                    |                                             |           | 630,844      |
| Prawn               | 1,125              |                             |                                                                    |                                             |           | 1,125        |
| Shrimp              | 9,569              |                             |                                                                    |                                             |           | 9,569        |
| Total pounds        | 333,654            | 2,061,845                   | 10,503,787                                                         | 5,749,244                                   | 1,416,411 | 20,064,941   |

\* These importations are included in tables of landings. They include fish caught by California boats in foreign waters as well as frozen fish imported for canning in California plants.



## CALIFORNIA FRESH FISH LANDINGS\* FOR JANUARY, FEBRUARY AND MARCH, 1937

Compiled by the Division of Fish and Game, Bureau of Marine Fisheries

| Species             | Region 10,<br>Del Norte | Region 20,<br>Eureka | Region 30,<br>Sacramento | Region 40,<br>San Francisco | Region 50,<br>Monterey | Region 60,<br>Santa Barbara | Region 70,<br>Los Angeles | Region 80,<br>San Diego | Total<br>pounds |
|---------------------|-------------------------|----------------------|--------------------------|-----------------------------|------------------------|-----------------------------|---------------------------|-------------------------|-----------------|
| Anchovy             |                         |                      |                          |                             | 14,480                 | 42                          | 6,738                     | 114,598                 | 21,218          |
| Barracuda           |                         |                      |                          | 450                         | 431                    | 18                          | 139,435                   |                         | 254,075         |
| Cabezone            |                         |                      |                          |                             |                        |                             |                           | 66,608                  | 89              |
| Cabrilla            |                         |                      |                          |                             |                        |                             | 21,366                    |                         | 87,734          |
| Carp                |                         |                      | 17,237                   |                             |                        |                             |                           |                         | 17,237          |
| Catfish             |                         |                      | 40,040                   |                             |                        |                             |                           |                         | 40,040          |
| Corbina, Mexican    |                         | 133,549              |                          | 83,937                      | 30,800                 | 357                         | 48,450                    |                         | 48,450          |
| Cottus, Pacific     | 2,532                   |                      |                          | 4                           |                        |                             | 307                       |                         | 251,482         |
| Ed.                 |                         |                      |                          |                             |                        |                             |                           |                         | 4               |
| Flounder, Slarry    |                         | 1,945                |                          | 294,735                     | 4,268                  |                             |                           |                         | 300,048         |
| Grouper             |                         |                      |                          |                             |                        |                             |                           |                         | 300,048         |
| Hake                |                         |                      |                          | 12,516                      |                        |                             | 1,930                     |                         | 38,067          |
| Habit, California   |                         |                      |                          | 3,717                       |                        |                             | 2,332                     | 36,137                  | 38,067          |
| Hallibut, Northern  |                         |                      |                          | 1,090                       | 10,595                 | 47,978                      | 152,833                   |                         | 14,848          |
| Haddock             | 51                      | 1,024                |                          |                             |                        |                             |                           | 195,316                 | 410,439         |
| Herring, Pacific    |                         | 6,495                | 17,207                   | 534,469                     | 600                    | 14                          |                           | 2,165                   | 17,207          |
| Kingfish            |                         |                      |                          |                             | 46,109                 |                             | 184,624                   | 3,012                   | 544,680         |
| Mackerel, Horse     |                         |                      |                          |                             | 526                    |                             | 1,183,723                 | 79                      | 230,812         |
| Mackerel, Pacific   |                         |                      |                          | 225                         | 443,657                | 3,396                       | 3,304,701                 | 18,480                  | 1,202,729       |
| Mackerel, Spanish   |                         |                      |                          |                             |                        |                             | 4,311                     | 312,639                 | 4,064,618       |
| Mullet              |                         |                      |                          |                             |                        |                             | 4,465                     | 2,889                   | 7,200           |
| Perch               | 78                      | 1,481                |                          | 38,067                      | 8,826                  | 1,320                       | 15,374                    |                         | 465             |
| Pile                |                         |                      | 246                      |                             |                        |                             |                           | 287                     | 65,442          |
| Pompano, California |                         |                      |                          |                             | 15                     |                             | 1,566                     |                         | 28,246          |
| Rock Bass           |                         |                      |                          |                             |                        | 1,509                       | 17,546                    | 9,839                   | 28,894          |
| Rockfish            | 7,101                   | 20,233               |                          | 201,432                     | 580,276                | 136,119                     | 149,257                   |                         | 1,213,983       |
| Sablefish           | 56                      | 16,409               |                          | 3,216                       | 819                    |                             | 84,752                    | 119,565                 | 105,252         |
| Salmon              |                         |                      | 40,870                   |                             | 27,334                 |                             | 9                         |                         | 68,213          |
| Sard Dab            |                         |                      |                          | 121,142                     | 309                    |                             | 3,215                     | 13                      | 124,679         |
| Sardine             |                         |                      | 12,476,500               | 16,042,715                  | 88,308,135             |                             | 231,009,184               | 9,138,021               | 356,974,555     |
| Sculpin             |                         |                      |                          |                             |                        | 13                          | 28,826                    | 4,307                   | 33,146          |
| Sea-bass, Black     |                         |                      |                          |                             | 36                     | 356                         | 59,533                    | 37,973                  | 97,898          |
| Sea-bass, Tornava   |                         |                      |                          |                             |                        |                             | 242,711                   | 19,640                  | 262,351         |
| Sea-bass, White     |                         |                      |                          |                             |                        |                             | 9,071                     | 13,628                  | 33,571          |
| Shad                |                         |                      |                          |                             | 528                    | 10,344                      |                           |                         | 10,962          |
| Shark               |                         |                      | 10,944                   | 178,918                     | 18                     |                             | 39,795                    | 16,520                  | 293,674         |
| Sheepshead          |                         |                      |                          |                             | 43,099                 |                             | 15,342                    | 2,796                   | 31,562          |
| Skate               |                         |                      |                          | 108,488                     | 4,561                  | 9,669                       | 19,097                    | 786                     | 132,928         |
| Smelt               |                         | 5,268                |                          | 100,926                     |                        | 11,849                      | 7,244                     |                         | 169,087         |
| Sole                | 30                      |                      |                          | 1,853,421                   | 38,361                 | 1,437                       | 53,612                    | 2,074                   | 1,942,128       |
| Spitt-tail          |                         |                      | 7,444                    |                             |                        | 49,259                      | 1,045                     | 12                      | 7,444           |
| Sucker              |                         |                      | 3,897                    |                             |                        |                             |                           |                         | 3,897           |
| Tomcod              |                         |                      |                          | 848                         |                        |                             |                           |                         | 848             |

|                    |        |         |            |            |            |         |             |            |             |
|--------------------|--------|---------|------------|------------|------------|---------|-------------|------------|-------------|
| Tuna, Albacore     |        |         |            |            | 206        | 22      | 136,977     | 215,402    | 136,977     |
| Tuna, Bonito       |        |         |            |            |            |         | 143,149     |            | 360,779     |
| Tuna, Oriental     |        |         |            |            |            |         | 82,010      |            | 82,010      |
| Tuna, Skipjack     |        |         |            |            |            |         | 1,782,499   | 641,696    | 2,424,195   |
| Tuna, Yellowfin    |        |         |            |            |            |         | 2,460,244   | 12,781,122 | 15,241,366  |
| Turbot             |        |         |            |            | 2,454      |         |             |            | 15,826      |
| Whitebait          | 15,904 | 3,321   | 13,372     |            | 216        |         |             |            | 22,278      |
| Whitefish          |        |         | 2,887      |            |            | 866     | 7,035       | 6,706      | 14,607      |
| Yellowtail         |        |         |            |            |            | 11      | 41,281      | 415,640    | 456,933     |
| Miscellaneous fish |        | 2,465   | 37,054     | 2          | 163        | 98      | 1,680       |            | 41,467      |
| Crustacean:        |        |         |            |            |            |         |             |            | 482,004     |
| Crab               | 3,924  | 38,352  | 438,584    |            | 1,700      | 44      | 1,116       |            | 1,166       |
| Crab, Rock         |        |         | 50         |            |            |         | 43,436      | 632,304    | 710,876     |
| Lobster, Spiny     |        |         |            |            |            | 35,136  | 1,125       |            | 2,017       |
| Prawn              |        |         |            |            | 892        |         |             |            | 166,283     |
| Shrimp             |        |         | 156,700    |            |            |         | 9,583       |            |             |
| Mollusk:           |        |         |            |            |            |         |             |            | 175,251     |
| Alalone            |        |         |            |            | 39,850     | 135,401 |             |            | 7,965       |
| Clam, Cockle       |        |         | 141        |            |            |         | 7,824       |            | 7,965       |
| Clam, Gaper        |        | 480     | 308        |            |            |         |             |            | 7,848       |
| Clam, Pismo        |        |         |            |            | 4,225      | 41,040  |             |            | 45,265      |
| Clam, Soft-shell   |        |         | 20,910     |            |            |         |             |            | 20,910      |
| Clam, Washington   |        | 6,975   | 710        |            |            |         |             |            | 7,685       |
| Mussel             |        |         |            |            | 1,490      |         |             |            | 1,490       |
| Octopus            |        | 291     | 589        |            |            |         |             |            | 9,167       |
| Oyster, Eastern    |        |         | 95,850     |            | 8,062      | 158     | 67          |            | 95,850      |
| Oyster, Japanese   |        |         | 85,795     |            |            |         |             |            | 115,927     |
| Oyster, Native     |        | 30,132  | 18,793     |            |            | 6       |             |            | 18,799      |
| Squid              |        |         | 325        |            | 18,880     |         | 31,285      |            | 50,490      |
| Total pounds       | 29,676 | 238,288 | 20,452,394 | 12,644,519 | 89,647,786 | 501,813 | 241,543,763 | 24,808,089 | 389,866,828 |

\* Importations of fresh fish from foreign countries included. See foreign importation tables.

## BUREAU OF PATROL

E. L. MACAULAY, Chief of Patrol.....San Francisco

### CENTRAL DISTRICT (Headquarters, Sacramento)

S. H. Lyons, Inspector in Charge.....Sacramento  
 L. E. Mercer, Warden, Flying Squad.....Sacramento  
 Ed Hughes, Assistant Warden, Flying Squad.....Sacramento  
 Chas. Sibeck, Warden, Launch "Rainbow".....Sacramento

#### Northern Division

Jos. H. Sanders, Captain in Charge.....Sacramento  
 A. H. Willard, Captain.....Nevada City  
     Sergeant.....Redding  
 A. A. Jordan, Warden, Modoc County.....Alturas  
 Brice Hammack, Warden, Siskiyou County.....Yreka  
 Fred R. Starr, Warden, Siskiyou County.....Dorris  
 C. L. Gourley, Warden, Trinity County.....Weaverville  
 Earl Caldwell, Warden, Shasta County.....Montgomery Creek  
 Chas. Love, Warden, Shasta County.....Redding  
 C. O. Fisher, Warden, Lassen County.....Susanville  
 W. C. Blewett, Warden, Plumas County.....Quincy  
 R. W. Anderson, Warden, Tehama County.....Red Bluff  
 E. C. Vail, Warden, Glenn County.....Willows  
 E. O. Wraith, Warden, Butte County.....Chico  
 A. Granstrom, Warden, Sierra County.....Downieville  
 Earl Hiscox, Warden, Nevada County.....Nevada City  
 R. A. Tinnin, Warden, Yuba County.....Challenge  
 L. W. Dinsdale, Warden, Sutter County.....Yuba City  
 Taylor London, Warden, Colusa County.....Colusa  
 R. L. Sinkey, Warden, Yolo County.....Woodland  
 W. J. Black, Warden, Solano County.....Suisun  
 H. S. Vary, Warden, Sacramento County.....Sacramento  
 Nelson Poole, Warden, Placer County.....Auburn  
 Albert Sears, Warden, El Dorado County.....Placerville

#### Southern Division

S. R. Gilloon, Captain in Charge.....Fresno  
 John O'Connell, Captain.....Stockton  
     Sergeant.....Bakersfield  
 Wm. Hoppe, Warden, San Joaquin County.....Lodi  
 R. J. Little, Warden, Amador County.....Jackson  
 J. W. Thornburg, Warden, Calaveras County.....Angels Camp  
 F. F. Johnston, Warden, Tuolumne County.....Sonora  
 Geo. Magladry, Warden, Stanislaus County.....Modesto  
 M. S. Clark, Warden, Merced County.....Merced  
 Ray Ellis, Warden, Kings County.....Hanford  
 Clarence Brown, Warden, Mariposa County.....Mariposa  
 H. E. Black, Warden, Madera County.....Madera  
 Paul Kehrre, Warden, Fresno County.....Fresno  
 F. A. Bullard, Warden, Fresno County.....Reedley  
 R. J. Bullard, Warden, Tulare County.....Porterville  
 W. I. Long, Warden, Tulare County.....Visalia  
 C. S. Donham, Warden, Merced County.....Gustine  
 Lester Arnold, Warden, Kern County.....Bakersfield  
 Roswell Welch, Warden, Kern County.....Kernville

### COAST DISTRICT (Headquarters, San Francisco)

K. P. Allred, Inspector in Charge.....San Francisco  
 Scott Feland, Warden, Flying Squad.....San Francisco  
 Eugene Durney, Assistant Warden, Flying Squad.....San Francisco

#### Northern Division

W. J. Harp, Captain in Charge.....Ukiah  
 J. D. Dondero, Captain.....Eureka  
 Henry Lencioni, Captain.....Santa Rosa  
 John Hurley, Warden, Humboldt County.....Eureka  
 W. F. Kalher, Warden, Humboldt County.....Fortuna  
 Ray Diamond, Warden, Mendocino County.....Willits